

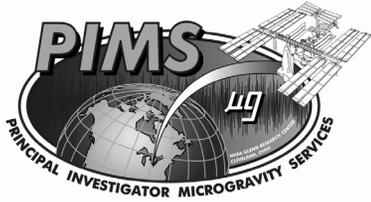
ISS Measured Vibratory Environment Section 20



International Space Station (ISS) Measured Vibratory Environment Increments 2 and 3

Principal Investigator Microgravity Services
(PIMS)

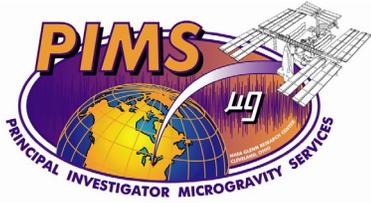
Kenneth Hrovat



ISS Measured Vibratory Environment Outline



- Two Viewpoints: Quasi-Steady & Vibratory
- Vibratory Acceleration Envelope
- Vehicle
 - Air conditioner [SKV]; Система Кондиционирования Воздуха (СКВ)
 - Docking
 - Structural modes
- Experiment
 - ADVanced ASTroCulture (ADVASC)
 - Experiment of Physics of Colloids in Space (EXPPCS)
- Crew
 - Sleep/Wake
 - Public Affairs Office (PAO) Event
 - Exercise
 - Active Rack Isolation System International Space Station Characterization Experiment (ARIS-ICE) Hammer Test
- Principal Component Spectral Analysis (PCSA)
- Summary



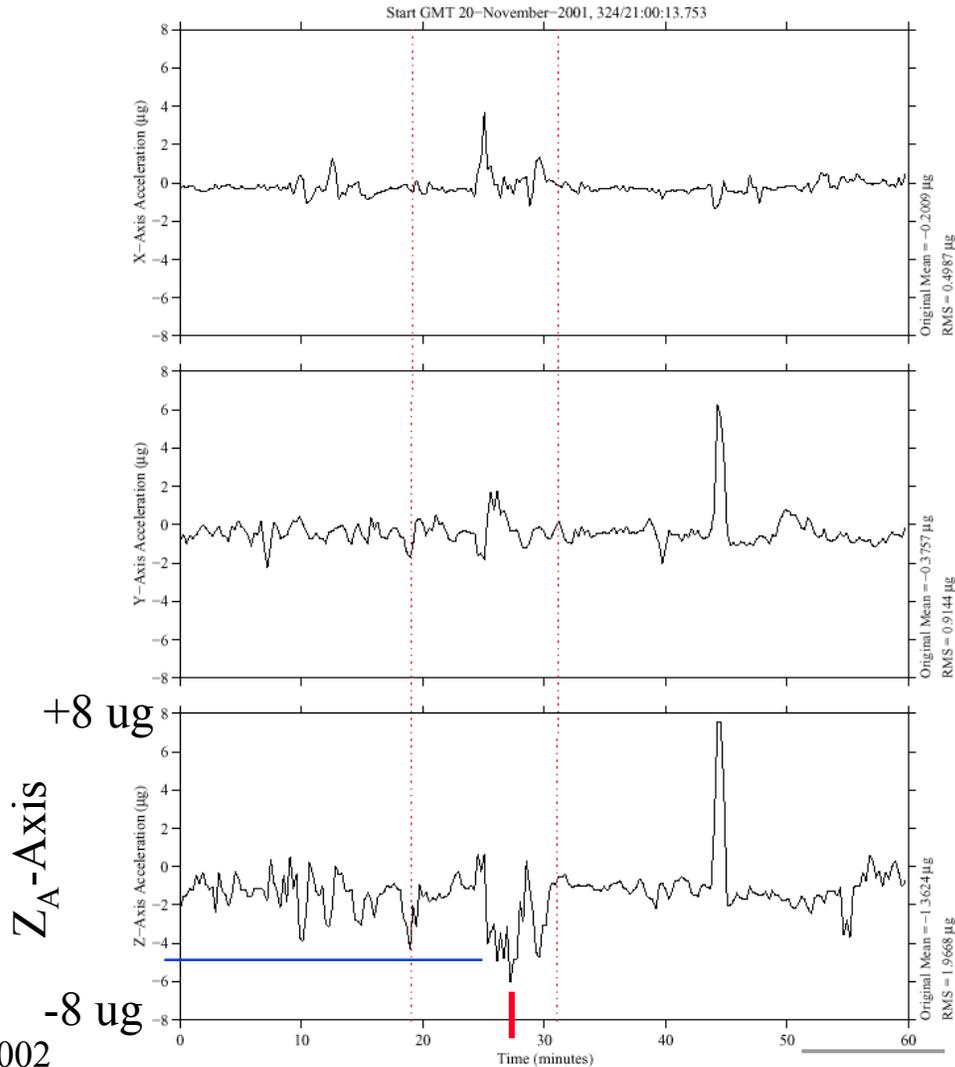
ISS Measured Vibratory Environment Quasi-Steady Viewpoint



mms, osbtmf at LAB102, ER1, Lockers 3,4-[135.28 -10.68 132.12]
0.0625 m/s² (1.0 Hz)

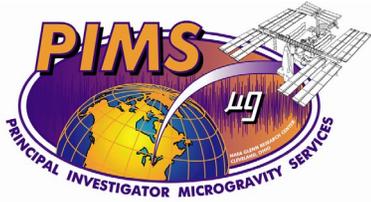
Increment: 3, Flight: 7A.1
SSAnalysis[0.0 0.0 0.0]

Progress 5P Oxygen Purge and Momentum Management



~ 5 μg DC (mean) shift on Z-axis for a few minutes

03/07/2002



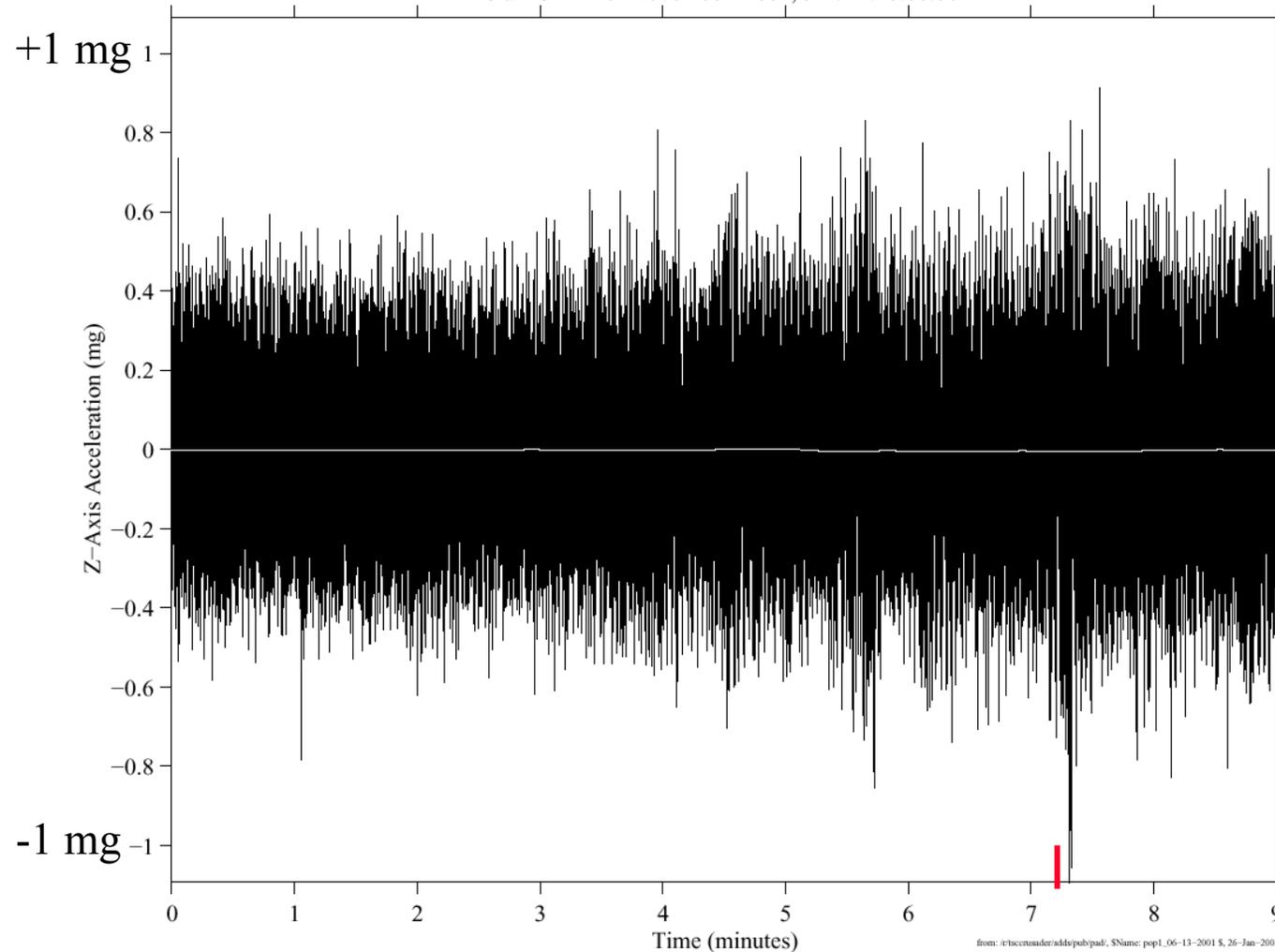
ISS Measured Vibratory Environment Vibratory Viewpoint



sams2, 121f05 at LAB1O1, ER2, Upper Z Panel:[185.17 38.55 149.93]
125.0 sa/sec (50.00 Hz)

Increment: 3, Flight: 7A.1
SSAnalysis[0.0 0.0 0.0]

Progress 5P Oxygen Purge, Compare Vibratory to Quasi-Steady
Start GMT 20-November-2001, 324/21:20:00.002



- **NOTES:**
 - time frame for this plot is 9-minute subset of the time shown on the previous slide
 - large (red) tick is at same time as that shown on the previous slide

white: quasi-steady
black: vibratory



ISS Measured Vibratory Environment Vibratory Acceleration Envelope



Frequency: $0.01 \leq f \leq 300$ Hz

Magnitude: from tens to thousands of μg_{RMS}

Primary Sources: vehicle, experiment....rotating machinery, structural dynamics
crew..... exercise, locomotion

International Space Station Microgravity Control Plan:

“... acceleration environment in the 0.01 to 300 Hz frequency range is produced by many simultaneous disturbance sources with varying duty cycles ...”

Important Vibratory Notes:

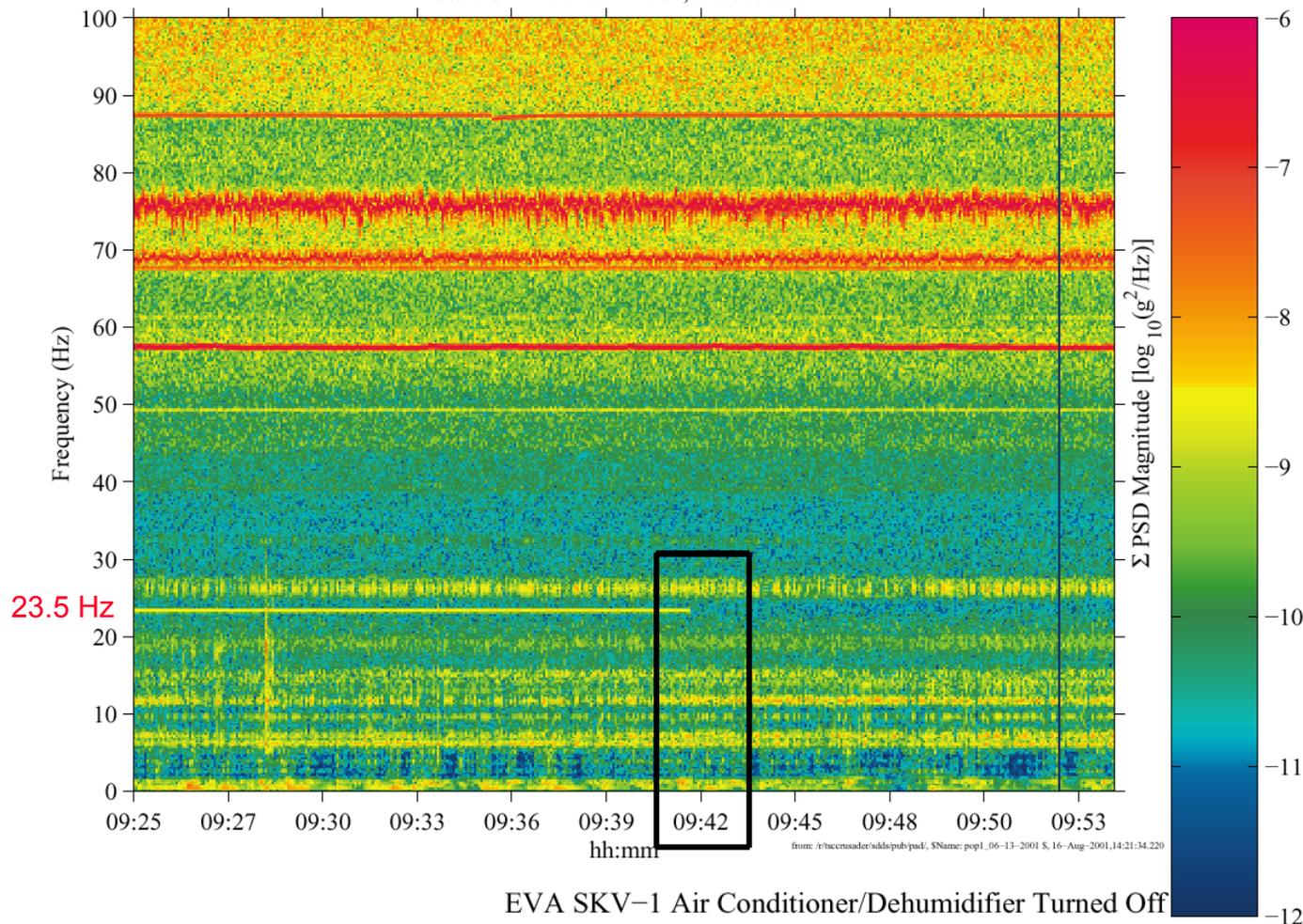
- Always demean vibratory data because vibratory sensors not intended for this purpose. If needed, then use Microgravity Acceleration Measurement System (MAMS), a dedicated instrument with special procedures to get precise accounting of quasi-steady (mean) value...
- Vibratory acceleration data is not mathematically mapped to other locations because rigid body assumption does not hold at higher frequencies.

ISS Measured Vibratory Environment Vehicle, Air Conditioner, Qualify

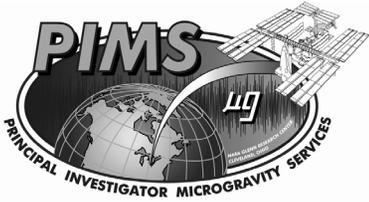
mams, hirap at LAB1O2, ER1, Lockers 3,4:[138.68 -16.18 142.35]
1000.0 sa/sec (100.00 Hz)
 $\Delta f = 0.244$ Hz, Nfft = 4096
Temp. Res. = 4.096 sec, No = 0

SKV-1 Air Conditioner/Dehumidifier Turn Off
Start GMT 08-Jun-2001,09:25:00.001

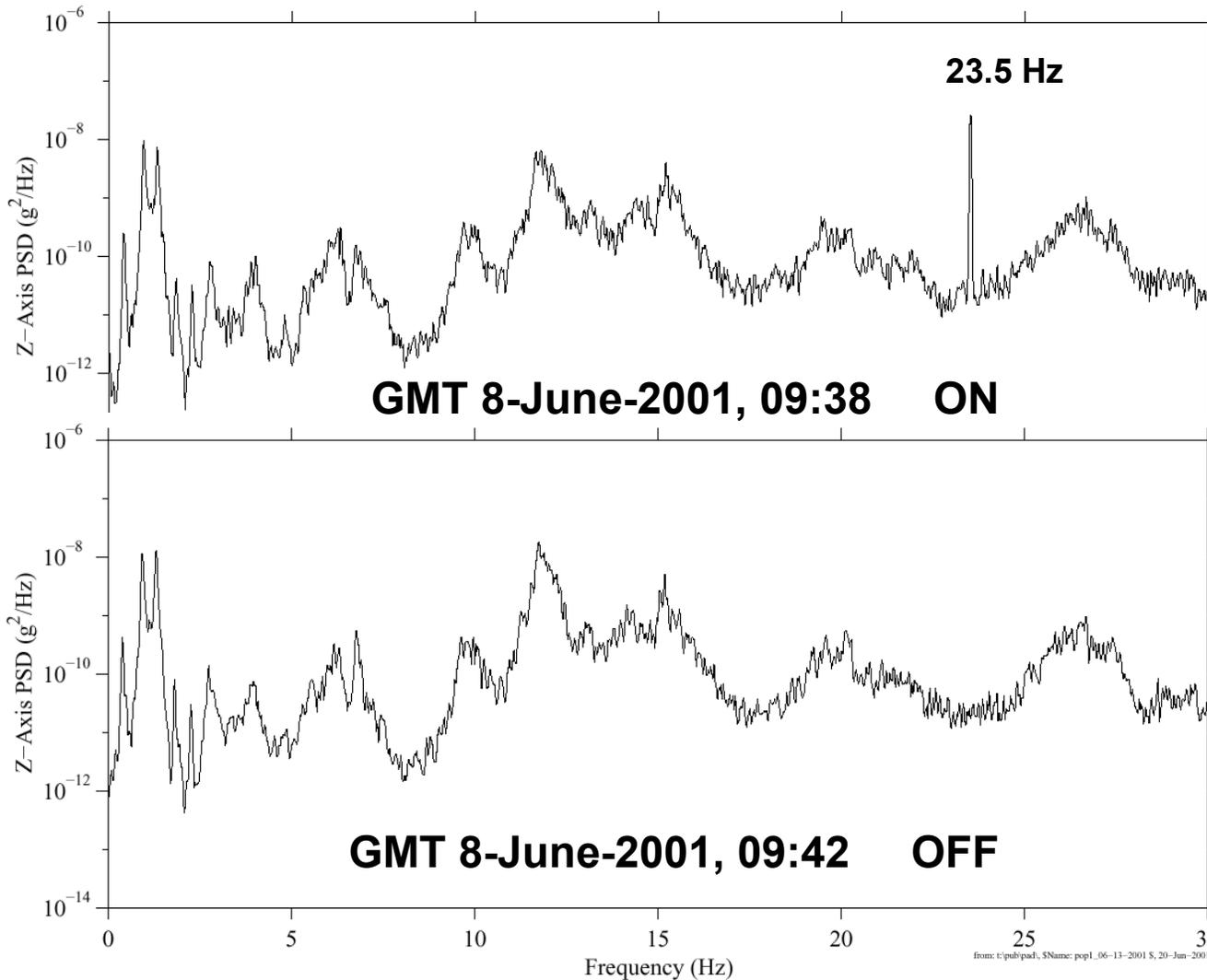
Increment: 2, Flight: 6A
Sum
Hanning, k = 439
Span = 29.90 minutes



- **SENSOR:**
 - MAMS HiRAP
 - in EXPRESS Rack 1 (ER1) lockers 3, 4
- **SOURCE:**
 - air conditioner
 - part of Environmental Control and Life Support System (ECLSS)
 - in the Functionalui Germaticeskii Block (FGB), Functional Cargo Block, Zarya
 - to prepare for an ExtraVehicular Activity (EVA) they had to move ducting to work with hatches and the deactivation shown was part of that procedure
- **EFFECT:**
 - narrowband, 23.5 Hz



ISS Measured Vibratory Environment Vehicle, Air Conditioner, Quantify



Pair, like this & previous slide, for each topic:

- qualify
- quantify
 - RMS: Parseval
 - PEAK: largest observed acceleration vector magnitude unless noted otherwise (like summary tables in PIMS increment reports)

Apply Parseval's theorem to sum of XYZ PSDs shows that at the ER1 location, the SKV-1 contributes ...

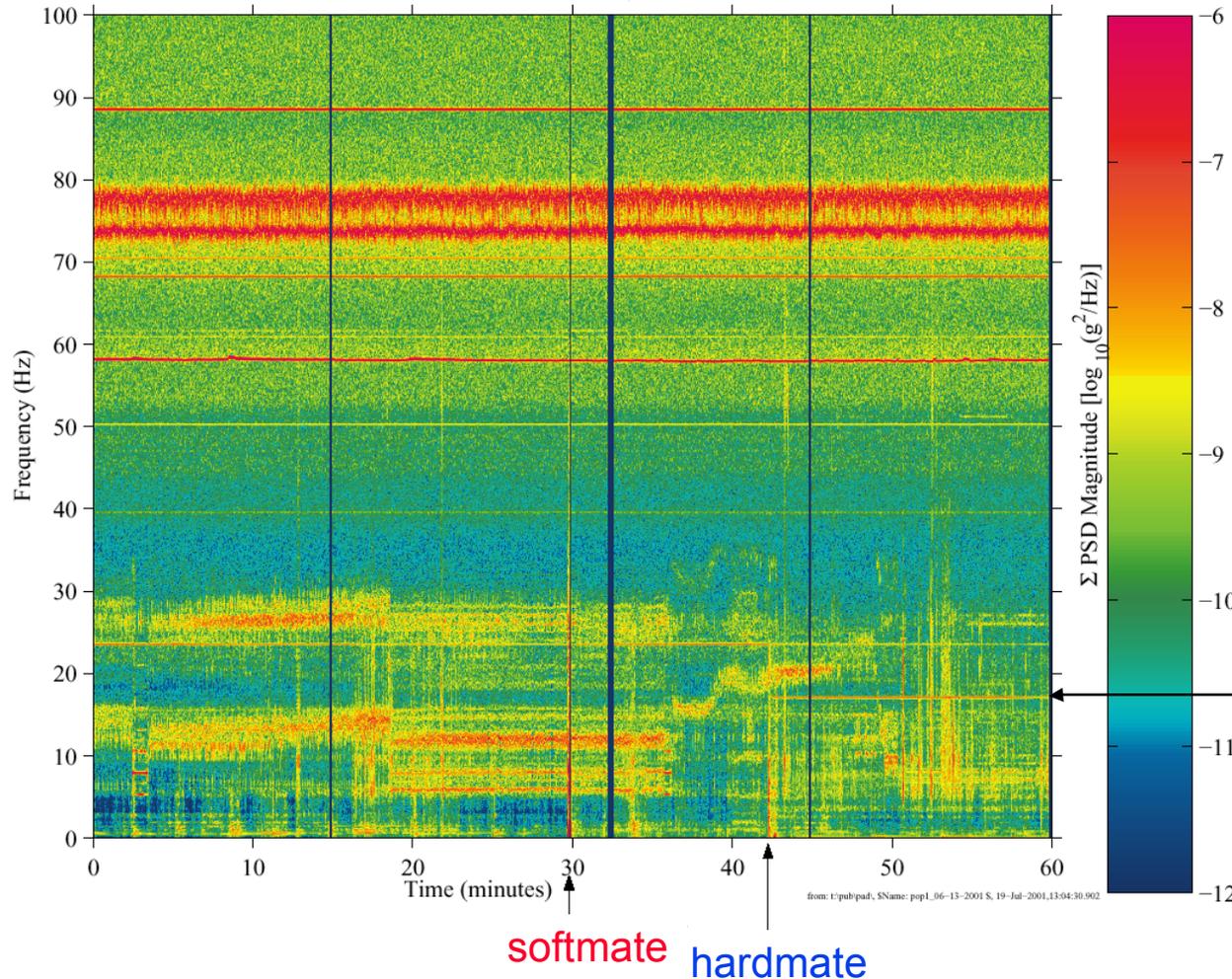
- **EFFECT:**
 - $23 \leq f \leq 24$ Hz
 - $\Delta \sim 30 \mu g_{RMS}$

ISS Measured Vibratory Environment Vehicle, Docking, Qualify

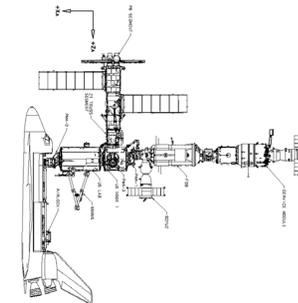
mams, hirap at LAB102, ER1, Lockers 3,4[138.68 -16.18 142.35]
1000.0 sa/sec (100.00 Hz)
 $\Delta f = 0.122$ Hz, Nfft = 8192
Temp. Res. = 4.096 sec, No = 4096

STS-104 Docking
Start GMT 14-Jul-2001,02:38:40.000

Increment: 2, Flight: 6A
Sum
Hanning, k = 866
Span = 60.01 minutes

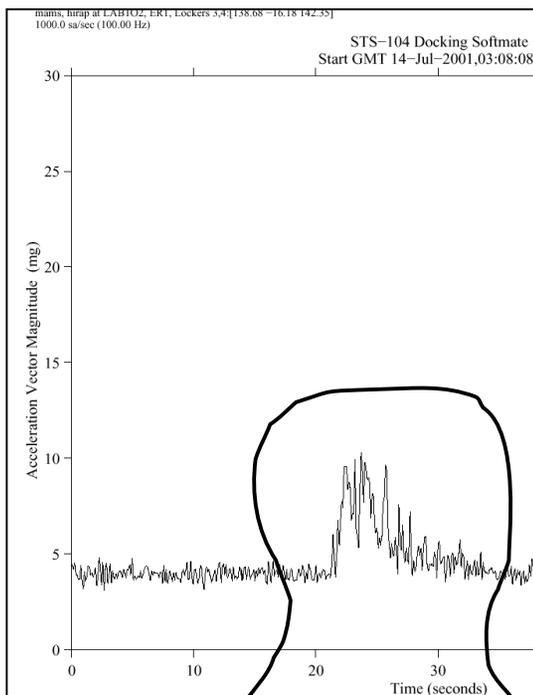


- **SENSOR:**
 - MAMS HiRAP
 - in ER1, lockers 3, 4
- **SOURCE:**
 - Shuttle: Atlantis STS-104, Flight 7A
 - docked at forward end of US Lab with Pressurized Mating Adapter (PMA-2)
- **EFFECT:**
 - broadband (impulsive) especially at softmate
 - narrowband, 17 Hz (with harmonics) from nearly continuous dither of Shuttle's Ku-band antenna

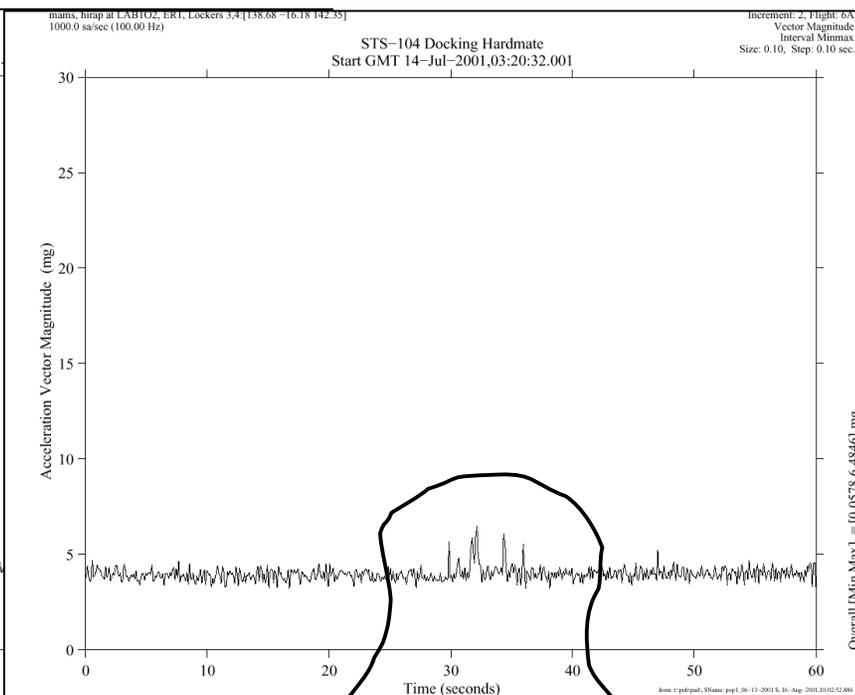




ISS Measured Vibratory Environment Vehicle, Docking, Quantify



softmate



hardmate

• EFFECT:

- STS-104
 - softmate PEAK: 10 mg
 - hardmate PEAK: 6 mg
 - Ku* 23 μg_{RMS}
- STS-105
 - softmate PEAK: 29 mg
 - hardmate PEAK: 14 mg
 - Ku* 42 μg_{RMS}

* Ku: $16.93 \leq f \leq 17.13$ Hz

Shuttle: $\sim 100\text{-}300 \mu\text{g}_{\text{RMS}}$

- see Increment 2 report for more details

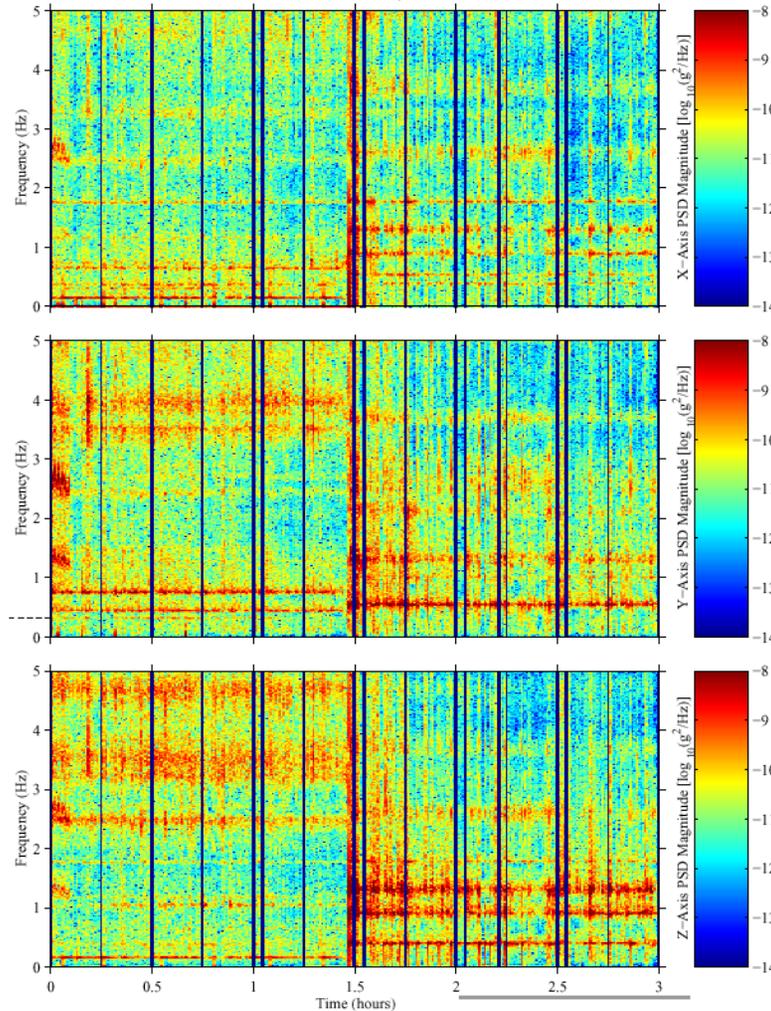
ISS Measured Vibratory Environment Vehicle, Structural Modes, Qualify

sams2_121f03 at LAB101, ER2, Lower Z Panel
250.0 sa/sec (100.00 Hz)
Δf = 0.015 Hz, Nfft = 16384
Temp. Res. = 32.768 sec, No = 8192

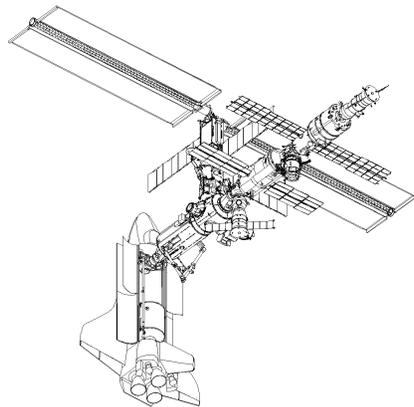
SAMS 121f03

Increment: 4, Flight: UF1
SSAnalysis[0.0 0.0 0.0]
Hanning, k = 2409

Start GMT 15-December-2001, 349/16:00:00.000



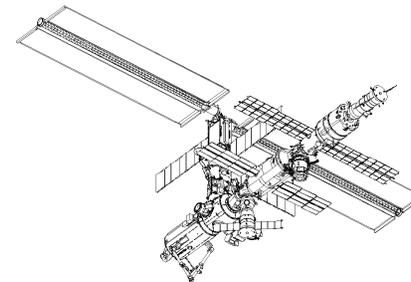
Joint Ops with Shuttle
Endeavour (Flight UF-1)



BEFORE

03/07/2002

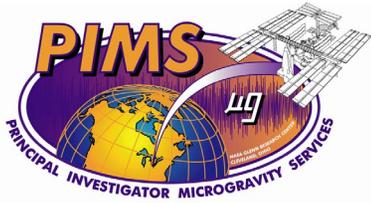
↑ STS-108 Undock



AFTER

MEIT-2002 / Section 20 / Page 10

- **SENSOR:**
 - SAMS RTS 121f03
 - on Z-panel of ER2
- **SOURCE:**
 - Flexing, bending, torsion of non-rigid parts.
- **EFFECT:**
 - nebulous, low-frequency
 - excited by impulsive events
 - modes will change as the ISS grows



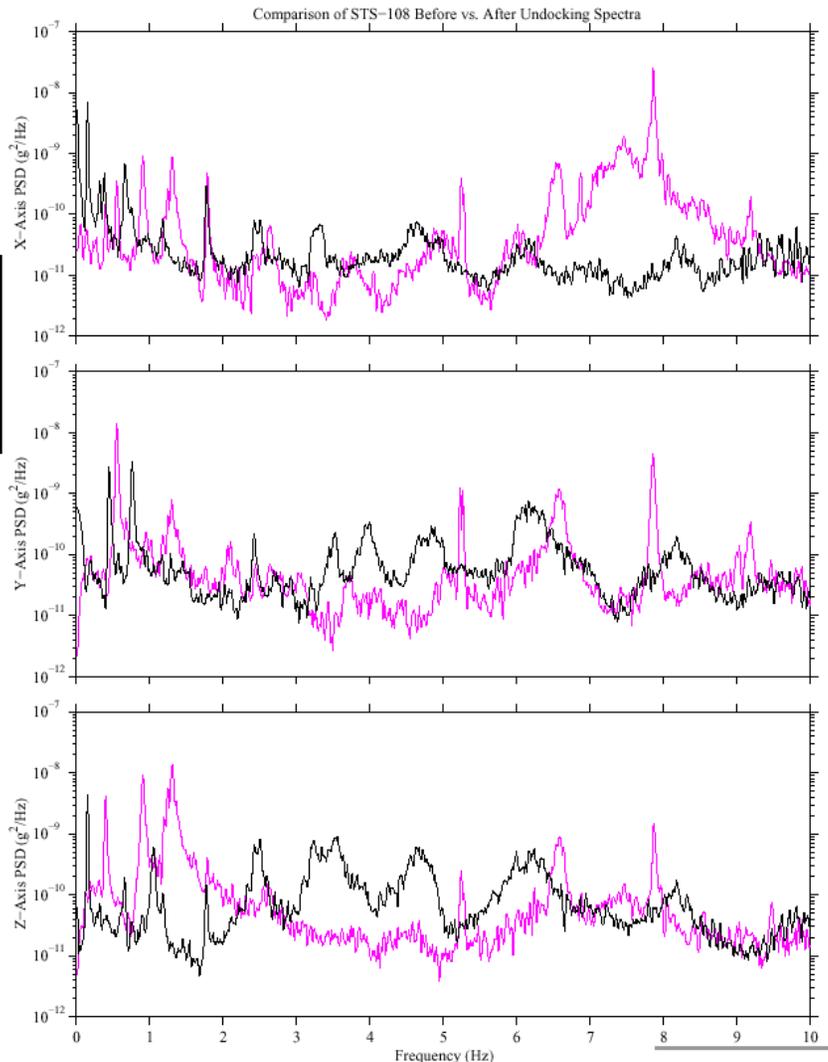
ISS Measured Vibratory Environment Vehicle, Structural Modes, Quantify



sams2
250.0 sa/sec (100.00 Hz)
Af= 0.015 Hz, Nf= 16384
P= 50%, No= 8192

Black: 121f04 "Joint Ops", Start GMT 15-December-2001, 349/16:30
Magenta: 121f03 "Unmated", Start GMT 15-December-2001, 349/18:30

Inc: 4, Flight: UF1, SSA



**121f04 "Joint Ops"
Before Undocking**

**121f03 "Unmated"
After Undocking**

- **EFFECT:**
 - narrowband
 - up to tens of μg_{RMS}
 - Increment 3 report details to compare SAMS RTS 121f03 to 121f04 (located in adjacent ERs)

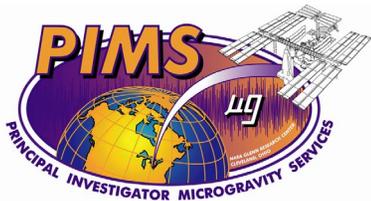
Table 2-6 Structural Mode Regime After STS-108 Undocked ("Unmated")

SSA	Frequency (Hz)	μg_{RMS}	Comment
-----	----------------	---------------	---------

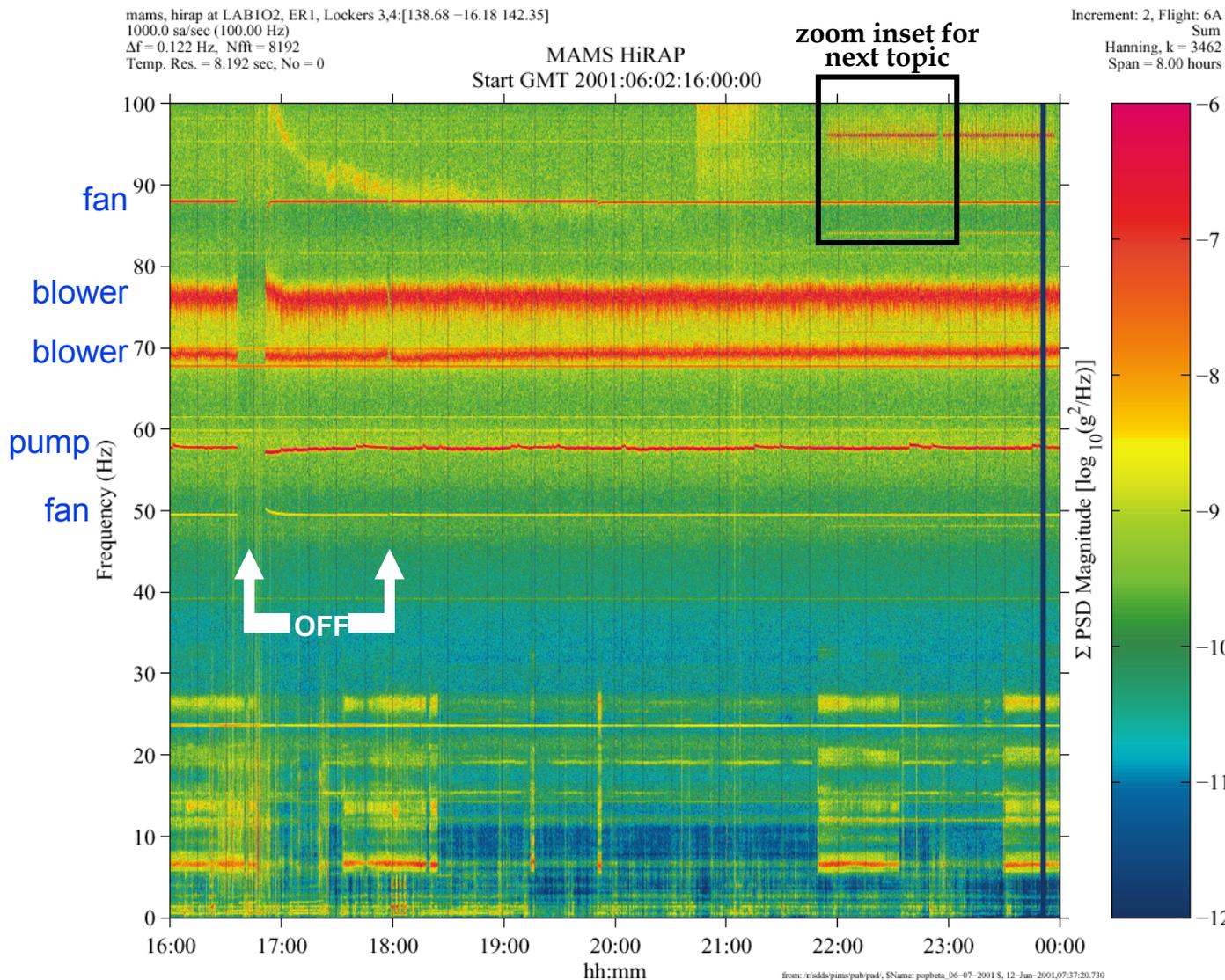
Table 2-5 Structural Mode Regime Before STS-108 Undocked ("Joint Ops")

SSA Axis	Frequency (Hz)				μg_{RMS}		Comment
	f_1	f_2	peak		121f03	121f04	
			121f03	121f04			
X	0.12	0.20	0.15	0.15	12.4	13.0	XZ
X	0.27	0.35	0.32	0.32	3.8	3.8	
X	0.35	0.43	0.38	0.38	4.3	4.3	
X	0.63	0.72	0.66	0.66	6.4	5.6	
X	0.72	0.79	0.75	0.75	2.6	2.6	
X	1.11	1.21	1.16	1.17	2.3	2.2	XZ
X	1.73	1.83	1.77	1.77	3.2	3.3	XZ
X	2.38	2.47	2.43	2.43	2.1	2.1	
X	2.47	2.58	2.50	2.50	2.3	2.3	
X	3.17	3.22	3.20	3.22	1.6	1.6	
X	3.22	3.40	3.30	3.31	3.3	3.0	
X	3.40	4.00	3.95	3.95	3.4	3.1	likely Shuttle born
X	4.40	5.00	4.67	4.64	5.2	5.1	likely Shuttle born
X	5.16	5.25	5.23	5.20	3.4	1.1	mainly 121f03
X	5.25	5.33	5.28	5.31	3.3	0.9	mainly 121f03
X	5.61	6.39	6.16	6.16	3.6	3.5	
X	6.74	7.40	7.23	7.13	3.8	2.7	mainly 121f03
X	7.78	7.99	7.86	7.84	20.1	1.1	mainly 121f03
X	7.69	7.95	7.90	7.90	4.3	0.8	mainly 121f03
X	9.12	9.26	9.19	9.17	2.7	1.5	mainly 121f03, XY
X	11.58	11.68	11.64	11.64	34.7	36.1	not a mode, on/off?
X	16.93	17.13	17.03	17.03	9.1	8.8	Shuttle born Ku antenna dither
Y	0.29	0.40	0.32	0.31	3.5	1.7	mainly 121f03
Y	0.40	0.53	0.44	0.44	8.9	9.4	
Y	0.69	0.89	0.76	0.76	12.7	11.9	Y
Y	2.37	2.49	2.43	2.43	3.3	3.5	
Y	3.40	4.00	3.94	4.00	12.0	8.7	likely Shuttle born

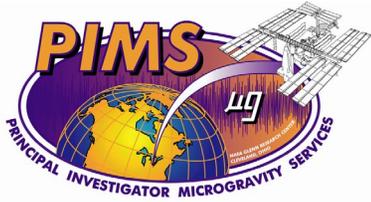
03/07/2002



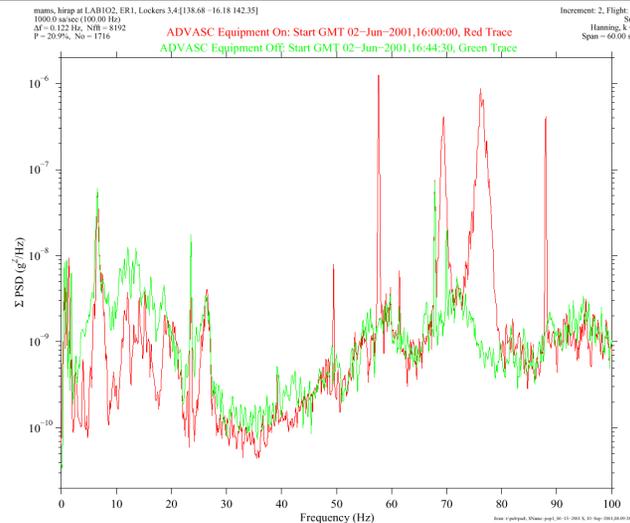
ISS Measured Vibratory Environment Experiment, ADVASC, Qualify



- **SENSOR:**
 - MAMS HiRAP
 - in ER1, lockers 3, 4
 - **SOURCE:**
 - ADVASC experiment equipment: pump, 2 fans, and 2 blowers
 - **EFFECT:**
 - broadband blowers, center expected* at about 72 and 78 Hz
 - narrowband pump and fans center expected* at about 53.5, 48 and 88 Hz, respectively
- * per e-mail on 9/17/2001 from Don Isham (ADVASC team at University of Wisconsin) from measurements made on ground



ISS Measured Vibratory Environment Experiment, ADVASC, Quantify



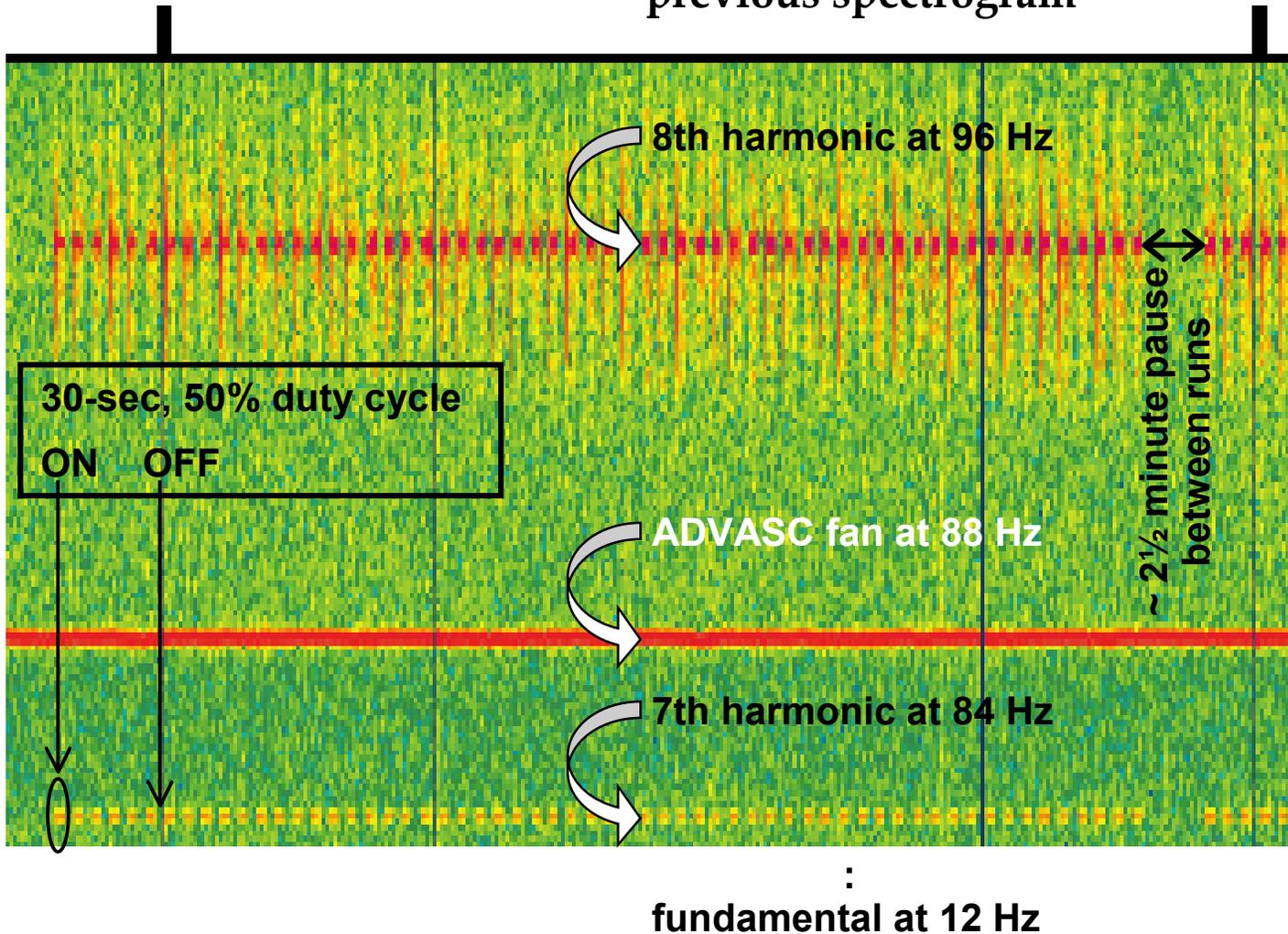
- **EFFECT:**
 - $f \leq 100$ Hz
 - ON: $1293 \mu g_{RMS}$
 - OFF: $436 \mu g_{RMS}$
 - Increment 2 report details
 - figure on p.127
 - table on p.39

NOTE: ON/OFF times are minutes:seconds relative to GMT 02-June-2001, Hour 16

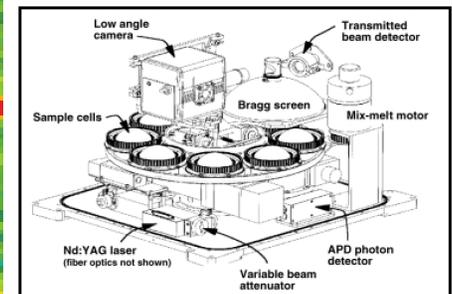
Frequency (Hz)			Disturbance Source	RMS Acceleration (μg_{RMS})		Note
Measured		Expected*		STATE		
Center	Range			ON 00:00-01:00	OFF 44:30-45:30	
49.4	49.1 - 49.7	48.3	2900 RPM fan	41.6	19.0	narrowband
57.6	57.3 - 57.9	52 - 55	air pump	568.9	31.4	narrowband
69.5	68.1 - 70.9	71.7	4300 RPM blower	512.9	97.4	broadband
76.5	73.0 - 79.7	78.3	4700 RPM blower	940.9	86.9	broadband
88.0	87.6 - 88.4	88.3	5300 RPM CPU fan	284.3	32.8	narrowband

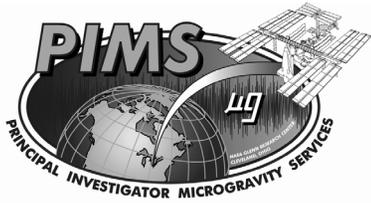
ISS Measured Vibratory Environment Experiment, EXPPCS, Qualify

zoom inset from
previous spectrogram



- **SENSOR:**
 - MAMS HiRAP
 - in ER1, lockers 3, 4
- **SOURCE:**
 - EXPPCS experiment equipment: sample mixer
- **EFFECT:**
 - depends on location
 - broadband near mixer; otherwise narrowband with fundamental of 12 Hz and harmonics, especially 9th harmonic at 108 Hz





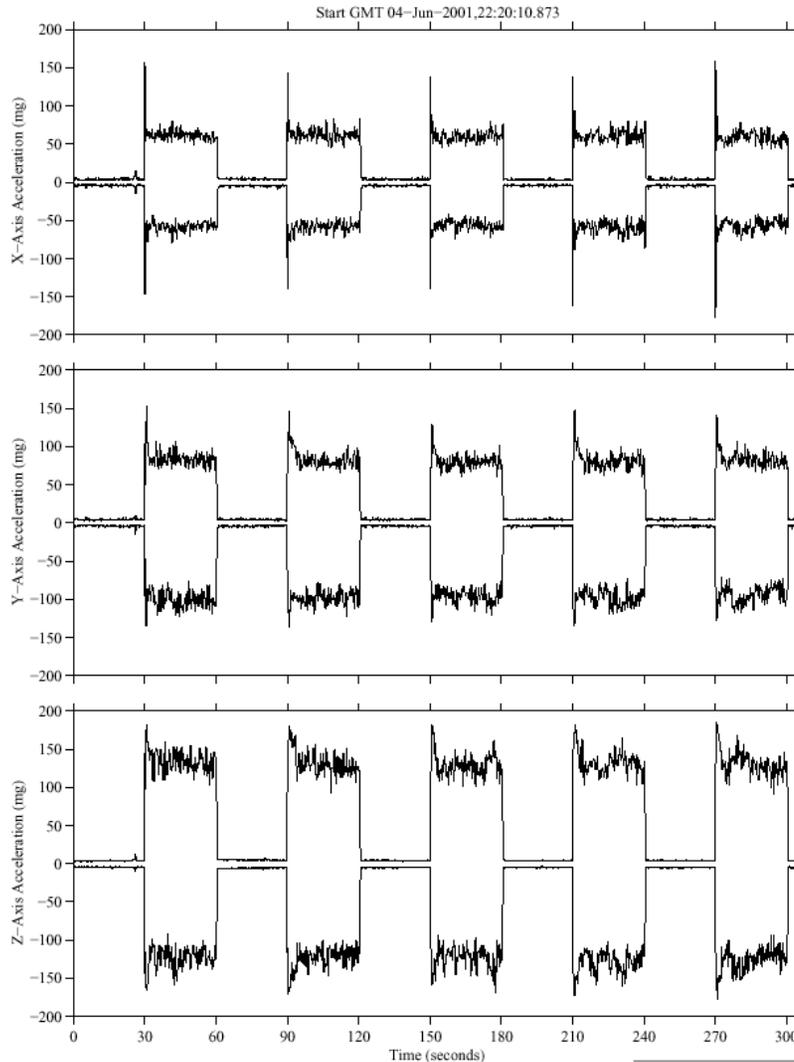
ISS Measured Vibratory Environment Experiment, EXPPCS, Quantify



sams2_121f06 at LAB101, ER2, PCS Test Section[179.90 - 6.44 145.55]
500.0 sa/sec (200.00 Hz)

Increment: 2, Flight: f
121f06[180.0 90.0 0.0
Interval Minm
Size: 0.25, Step: 0.25 a

30-Second Duty Cycle of EXPPCS Sample Mix Operations



Shuttle Primary
Reaction Control
System (PRCS)
Thruster Firing
~ 50 mg

- **SENSOR:**
 - SAMS RTS 121f06
 - about 1½ feet from the mixer in ER2
- **EFFECT:**
 - $f \leq 200$ Hz
 - PEAK: 150 mg
 - broadband near mixer; otherwise narrowband with fundamental of 12 Hz and harmonics, especially 9th harmonic at 108 Hz

GMT	Sensor	Frequency Range (Hz)	Peak Magnitude (mg)
04-June-2001	SAMS 121f06 ER2 test section	$f < 200$	150
05-July-2001	SAMS 121f03 ER2 Z-panel	$f < 100$	22
05-July-2001	SAMS 121f04 ER1 Z-panel	$f < 100$	10

03/07/2002



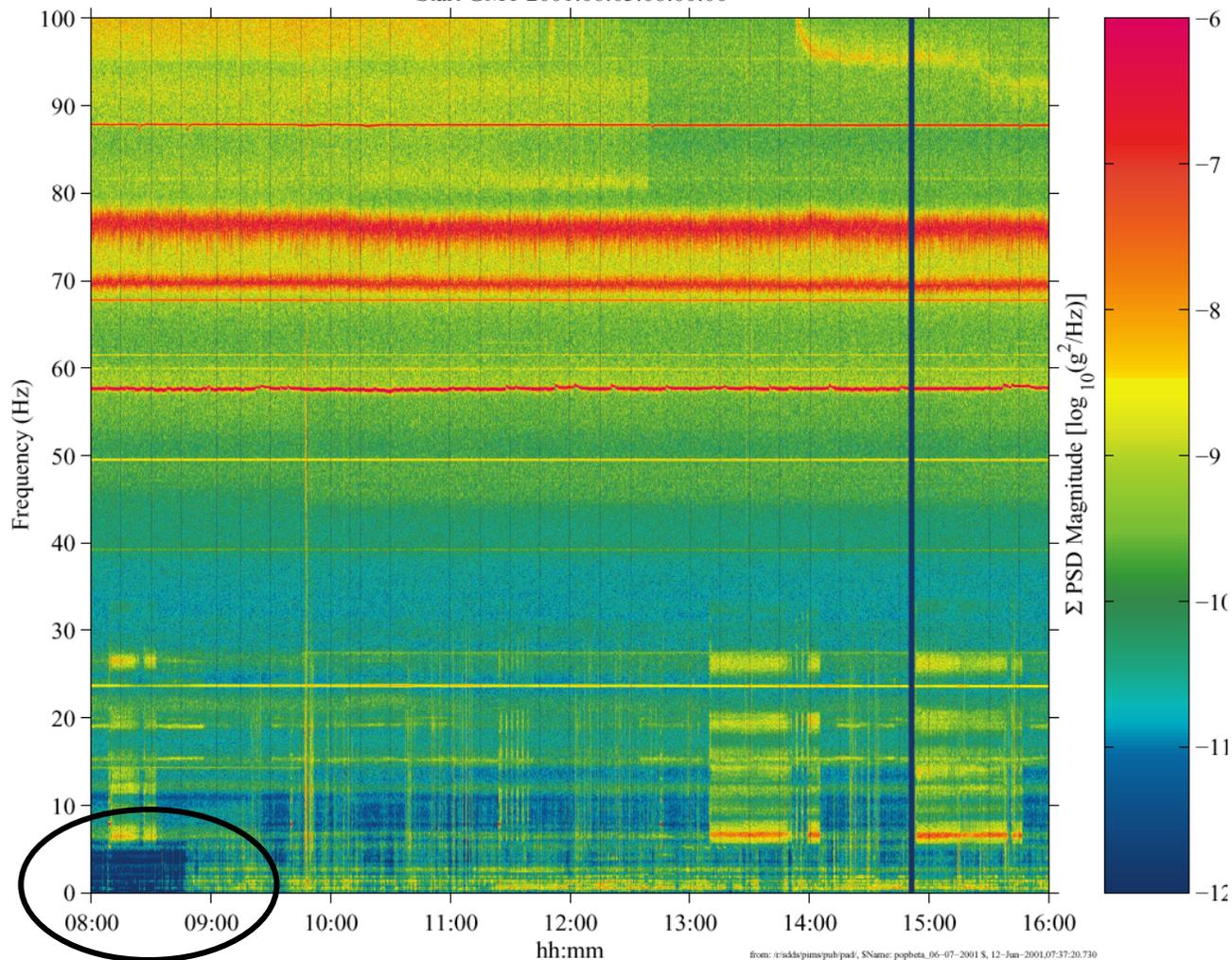
ISS Measured Vibratory Environment Crew, Sleep/Wake, Qualify



mams_hirap at LAB102, ER1, Lockers 3,4:[138.68 -16.18 142.35]
 1000.0 sa/sec (100.00 Hz)
 $\Delta f = 0.122$ Hz, $N_{fft} = 8192$
 Temp. Res. = 8.192 sec, No = 0

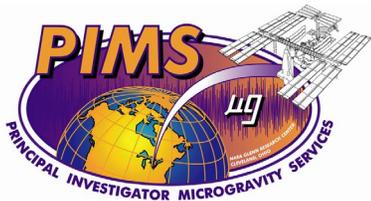
MAMS HiRAP
 Start GMT 2001:06:03:08:00:00

Increment: 2, Flight: 6A
 Sum
 Hanning, k = 3466
 Span = 8.00 hours



- **SENSOR:**
 - MAMS HiRAP
 - in ER1, lockers 3, 4
- **SOURCE:**
 - crew activity: pushoffs, landings, stowage, experiment operations, vehicle maintenance, exercise, ...
 - nominal 67% duty cycle
~16 hours wake and
~8 hours sleep
- **EFFECT:**
 - broadband, low-frequency

03/07/2002



ISS Measured Vibratory Environment Crew, Sleep/Wake, Quantify

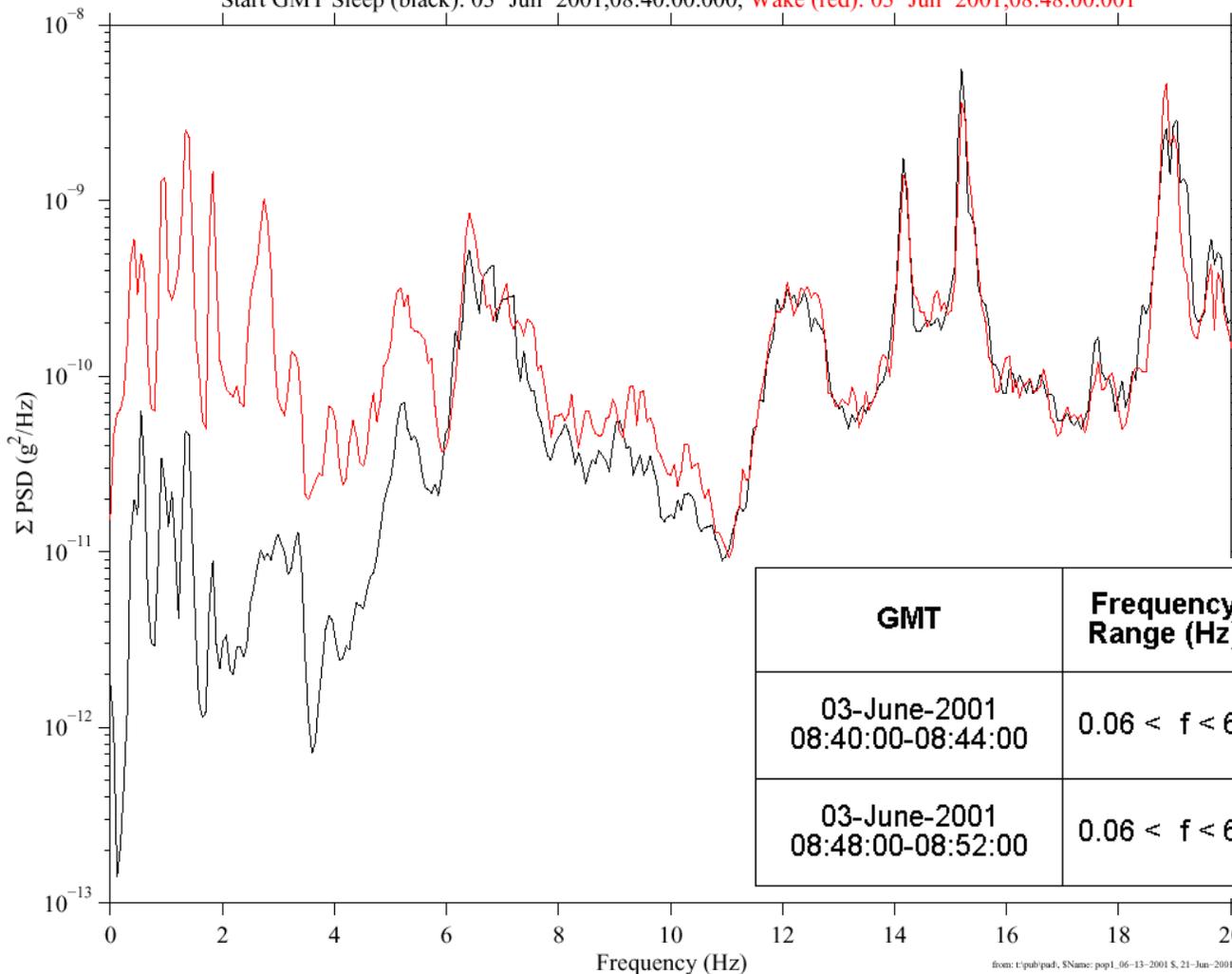


mams, hirap at LAB102, ER1, Lockers 3,4:[138.68 -16.18 142.35]
 1000.0 sa/sec (100.00 Hz)
 $\Delta f = 0.061$ Hz, Nfft = 16384
 P = 45.3%, No = 7430

Increment: 2, Flight: 6A
 Sum
 Hanning, k = 26
 Span = 240.00 sec.

Crew Activity Comparison

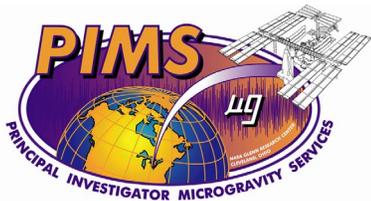
Start GMT Sleep (black): 03-Jun-2001,08:40:00.000, Wake (red): 03-Jun-2001,08:48:00.001



- **EFFECT:**
- $0.06 \leq f \leq 6$ Hz
- $\Delta \sim 30 \mu g_{RMS}$

GMT	Frequency Range (Hz)	State	RMS Acceleration (μg_{RMS})
03-June-2001 08:40:00-08:44:00	$0.06 < f < 6$	SLEEP	9
03-June-2001 08:48:00-08:52:00	$0.06 < f < 6$	WAKE	40

from: I:\pub\pad, SName: pop1_06-13-2001 S_21-Jun-2001,10-59:48.005



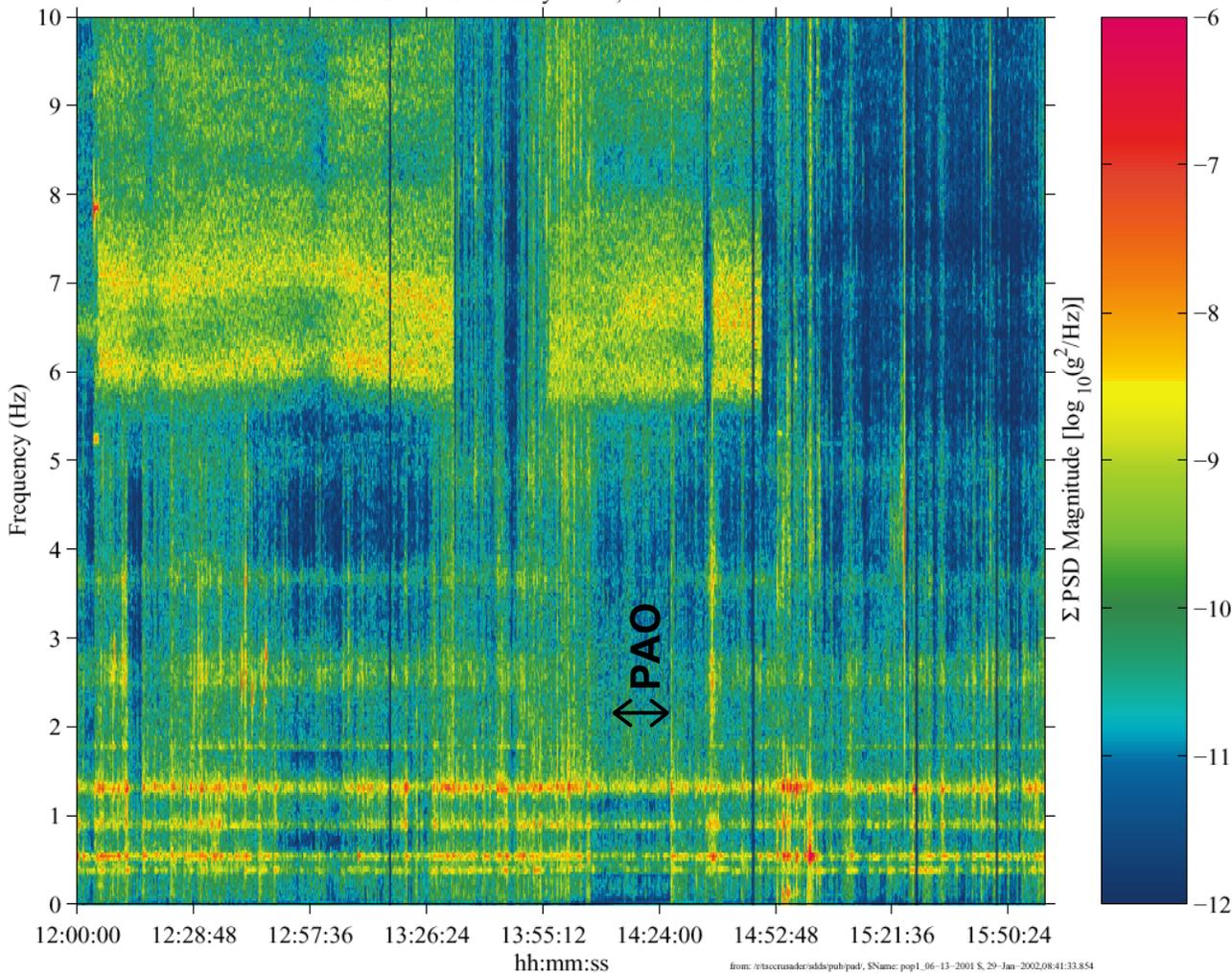
ISS Measured Vibratory Environment Crew, PAO Event, Qualify



sams2, 121f05 at LAB1O1, ER2, Upper Z Panel:[185.17 38.55 149.93]
62.5 sa/sec (25.00 Hz)
 $\Delta f = 0.031$ Hz, Nfft = 2048
Temp. Res. = 8.192 sec, No = 1536

Increment: 4, Flight: UF1
Sum
Hanning, k = 1755
Span = 239.48 minutes

PAO Event
Start GMT 03-January-2002, 003/12:00:00.009

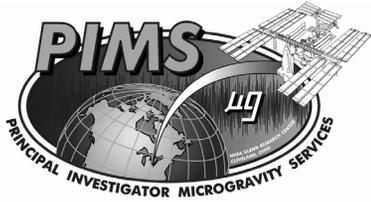


- **SENSOR:**
 - SAMS RTS 121f05
 - on light tray ("top") of ER2
- **SOURCE:**
 - During PAO events, most or all of the crew usually gathered in one location (in front of a camera) and relatively still. This one was with Jane Clayson of CBS, then Miles O'Brian of CNN.
- **EFFECT:**
 - broadband quieting below 5 Hz

03/07/2002

time ticks match those on next slide

MEIT-2002 / Section 20 / Page 18



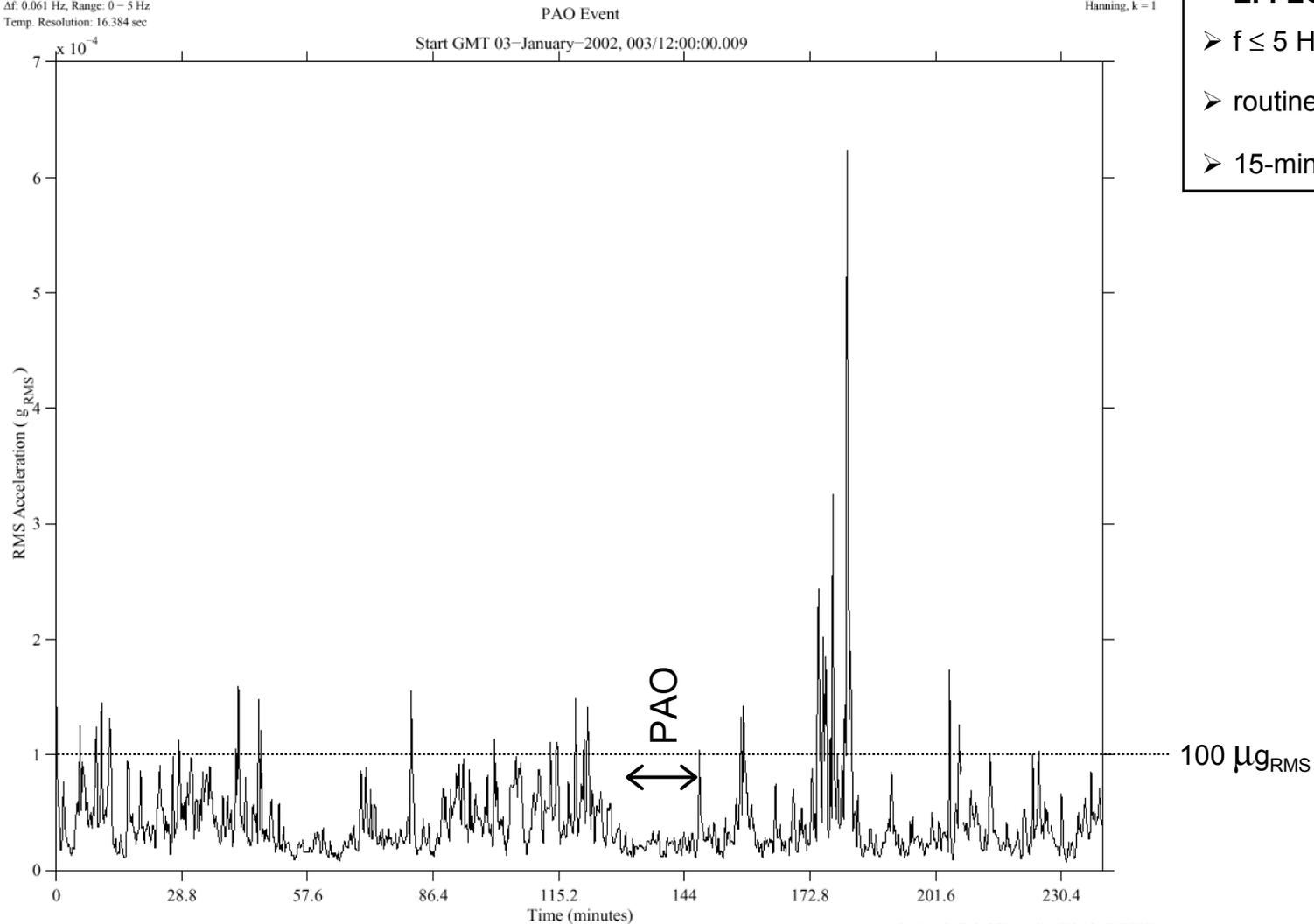
ISS Measured Vibratory Environment Crew, PAO Event, Quantify



sams2, 121f05 at LAB101, ER2, Upper Z Panel:[185.17 38.55 149.93]
62.5 sa/sec (25.00 Hz)
 Δf : 0.061 Hz, Range: 0 - 5 Hz
Temp. Resolution: 16.384 sec

Increment: 4, Flight: UF1
121f05[90.0 0.0 90.0]
Hanning, k = 1

- **EFFECT:**
- $f \leq 5$ Hz
- routinely $> 100 \mu g_{RMS}$
- 15-min. PAO $< 37 \mu g_{RMS}$



from: v:\acronyms\akki\pub\pd, 53Name: pop1_00-13-2001 & 29-Jan-2002,00:45:28.811

03/07/2002

time ticks match those on previous slide



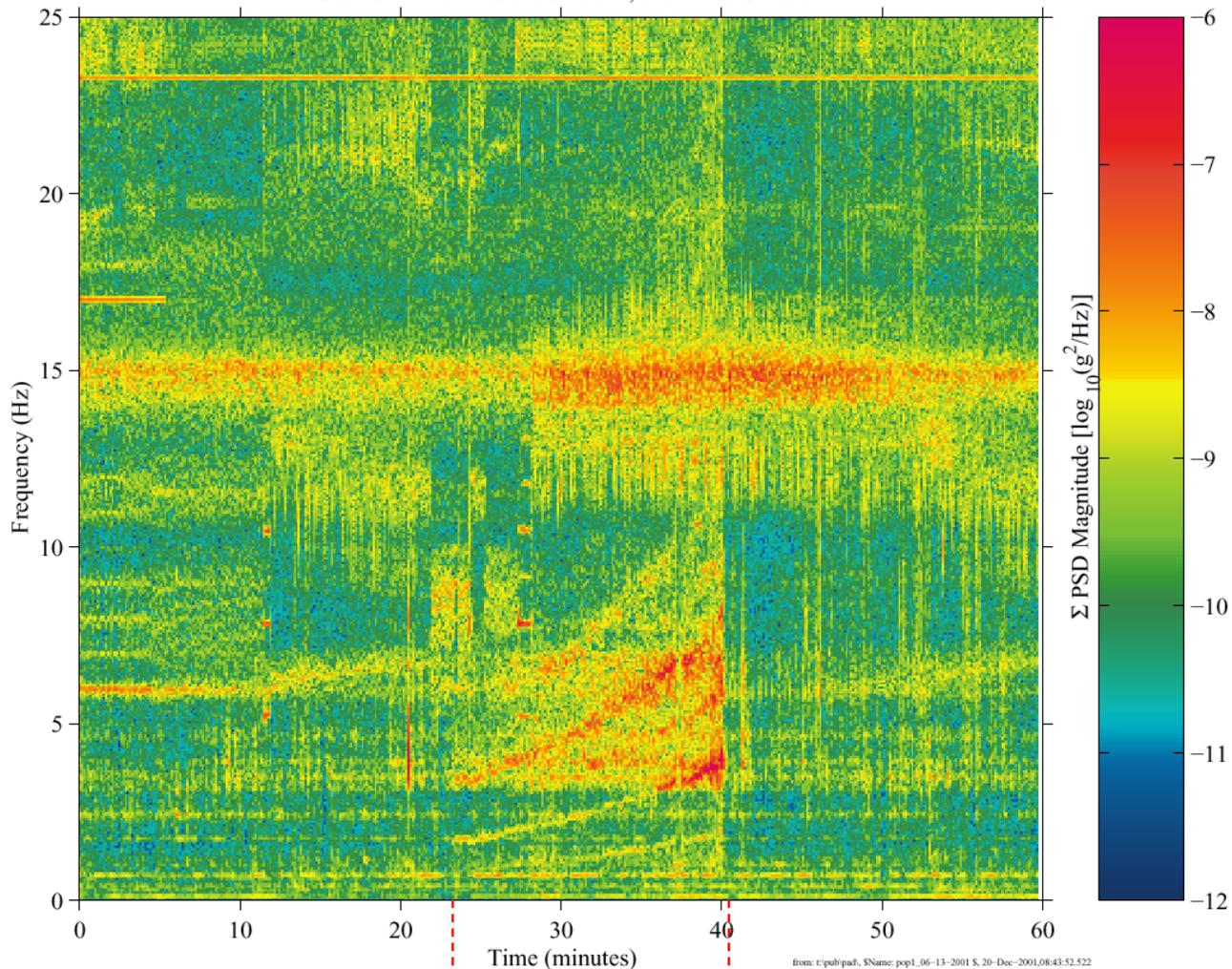
ISS Measured Vibratory Environment Crew, Unusual Exercise, Qualify



sams2, 121f03 at LAB101, ER2, Lower Z Panel:[191.54 -40.54 135.25]
 250.0 sa/sec (100.00 Hz)
 $\Delta f = 0.061$ Hz, Nfft = 4096
 Temp. Res. = 8.192 sec, No = 2048

STS-108 Shuttle Ergometer Exercise
 Start GMT 15-December-2001, 349/11:12:30.000

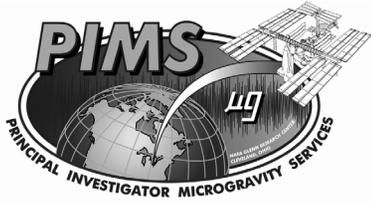
Increment: 4, Flight: UF1
 Sum
 Hanning, k = 438
 Span = 59.67 minutes



03/07/2002

- **SENSOR:**
 - SAMS RTS 121f03
 - on Z-panel of ER2
- **SOURCE:**
 - Non-typical exercise with ergometer in Shuttle during STS-108 joint operations; part of a detailed test objective (DTO-262)
 - Increment 3 report details

- **ISS EXERCISE EQUIPMENT:**
 - Russian velo ergometer in the Service Module
 - US Treadmill with Vibration Isolation System (TVIS) in the Service Module
 - US Cycle Ergometer with Vibration Isolation System (CEVIS) in the US Lab
 - US Resistive Exercise Device (RED) in Node 1



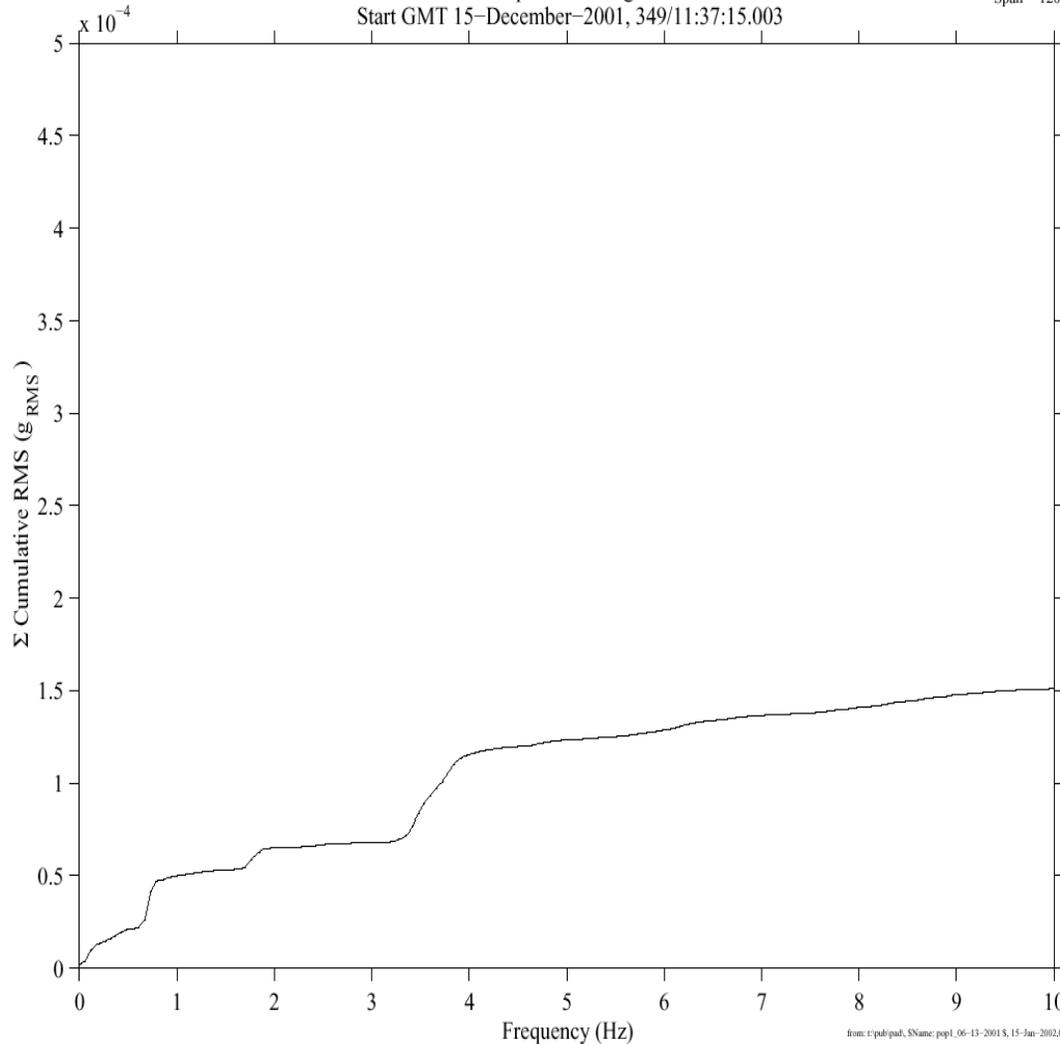
ISS Measured Vibratory Environment Crew, Unusual Exercise, Quantify



sams2, 121f03 at LAB101, ER2, Lower Z Panel:[191.54 -40.54 135.25]
250.0 sa/sec (100.00 Hz)
Δf = 0.061 Hz, Nfft = 4096

Increment: 4, Flight: UF1
Sum
Hanning, k = 7
Span = 120.00 sec.

STS-108 Joint Ops Shuttle Ergometer Exercise
Start GMT 15-December-2001, 349/11:37:15.003

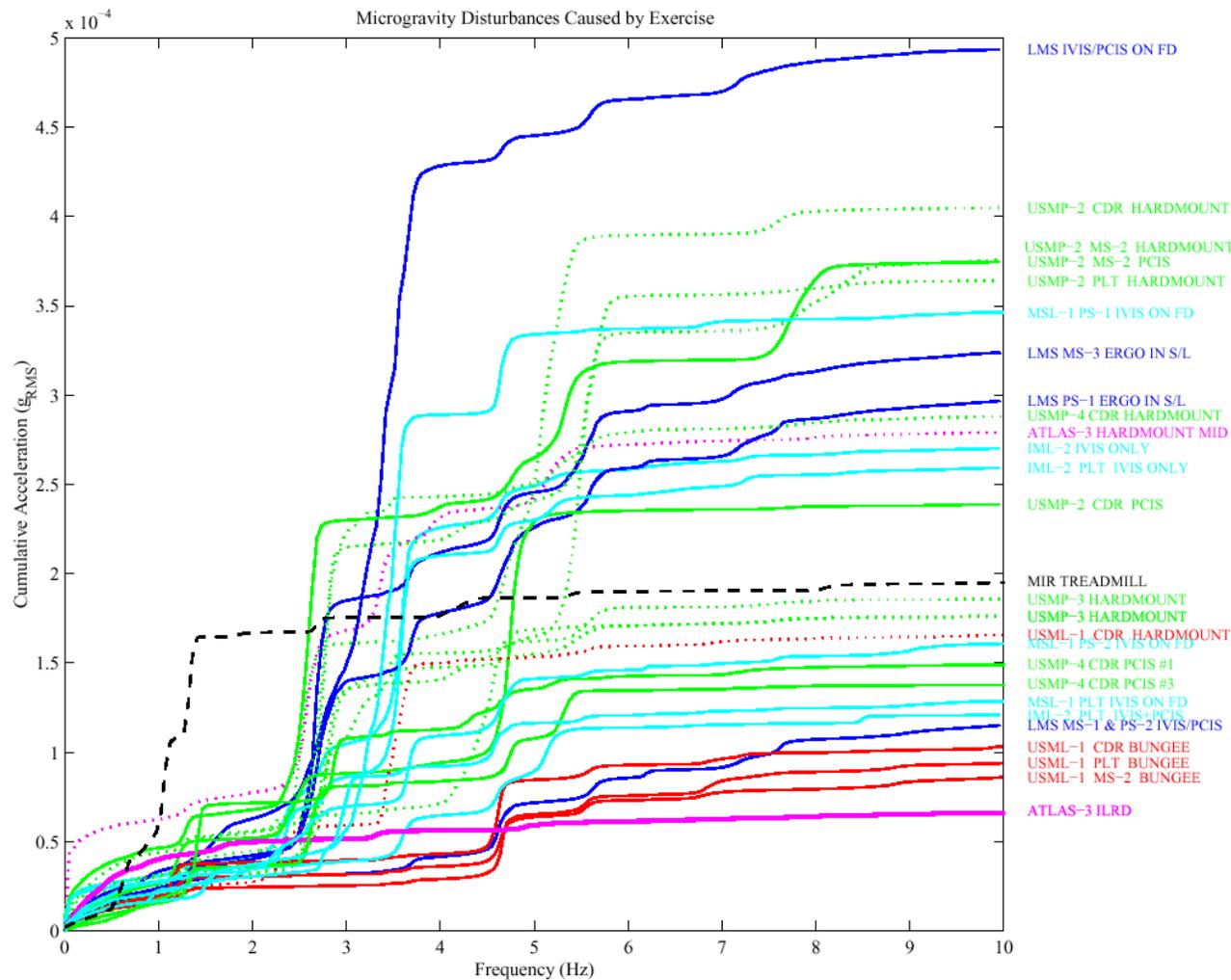


- **EFFECT:**
 - $f \leq 10$ Hz
 - $\sim 150 \mu g_{RMS}$

- **NOTES:**
 - this plot corresponds to the first 2 minutes of the 17-minute period shown with red ticks on previous slide
 - squeezed axis box for this plot so that it matches next slide

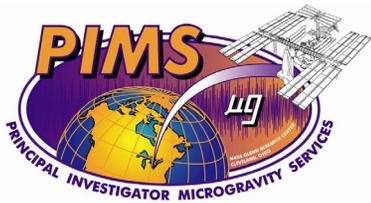
03/07/2002

ISS Measured Vibratory Environment Crew, Exercise, Mollify



- **SENSOR:**
 - various SAMS sensors
- **SOURCE:**
 - various exercise on Shuttle and Mir over a number of missions
- **EFFECT:**
 - “twin peaks” from shoulder sway and pedaling frequency with excitation of Shuttle structural modes at about 3.5 and 4.8 Hz

- **NOTES:**
 - the axis box for this plot matches previous slide
 - on Shuttle, regardless of vibration isolation used, the impact of crew exercise is dominated by vigor of individual crew



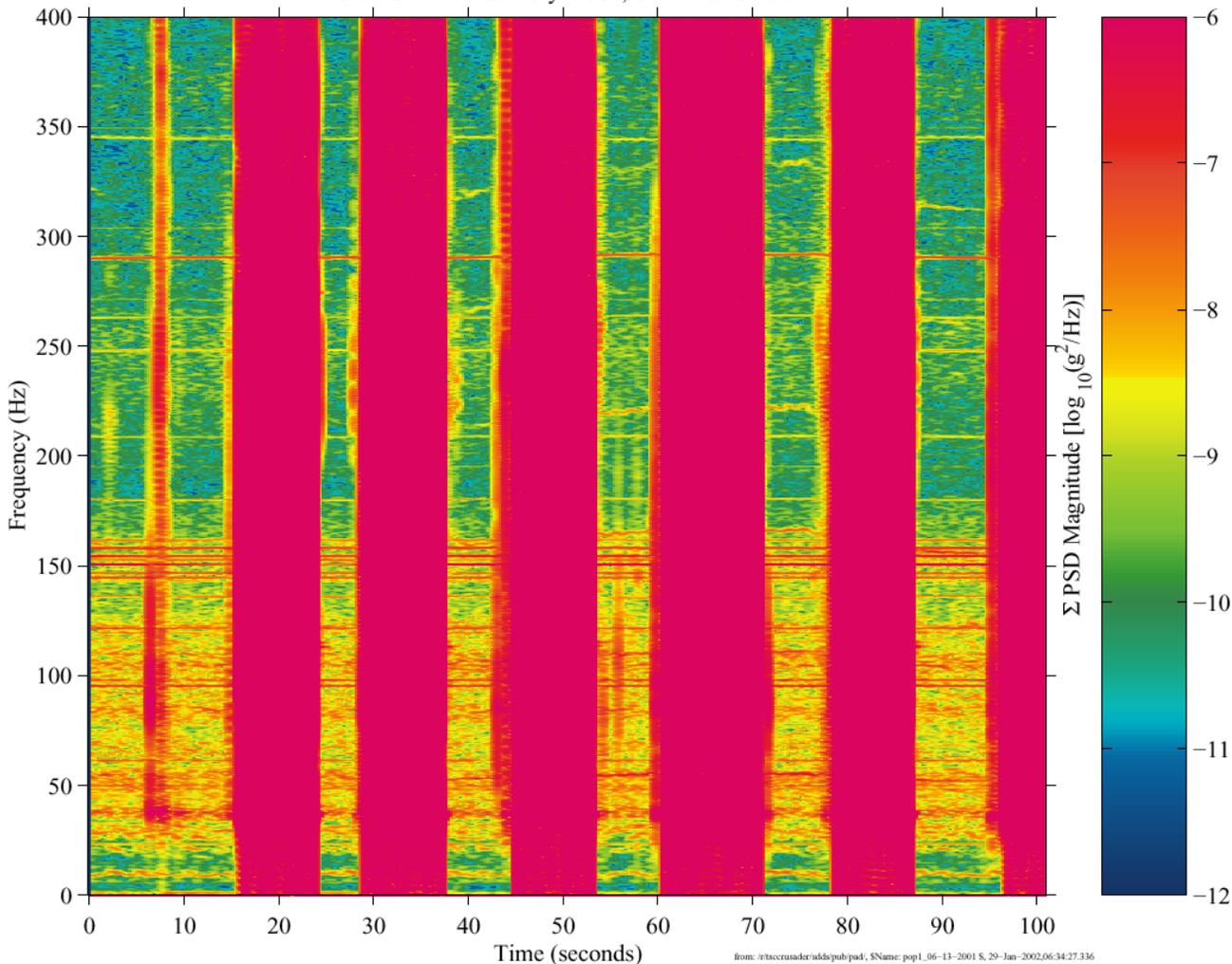
ISS Measured Vibratory Environment Crew, Experiment Operations, Qualify



sams2, 121f03 at LAB101, ER2, Lower Z Panel:[191.54 -40.54 135.25]
 1000.0 sa/sec (400.00 Hz)
 $\Delta f = 0.488$ Hz, Nfft = 2048
 Temp. Res. = 0.205 sec, No = 1843

ARIS-ICE Hammer Test #3 of 3
 Start GMT 22-January-2002, 022/17:09:38.000

Increment: 4, Flight: UF1
 Sum
 Hanning, k = 493
 Span = 100.86 seconds

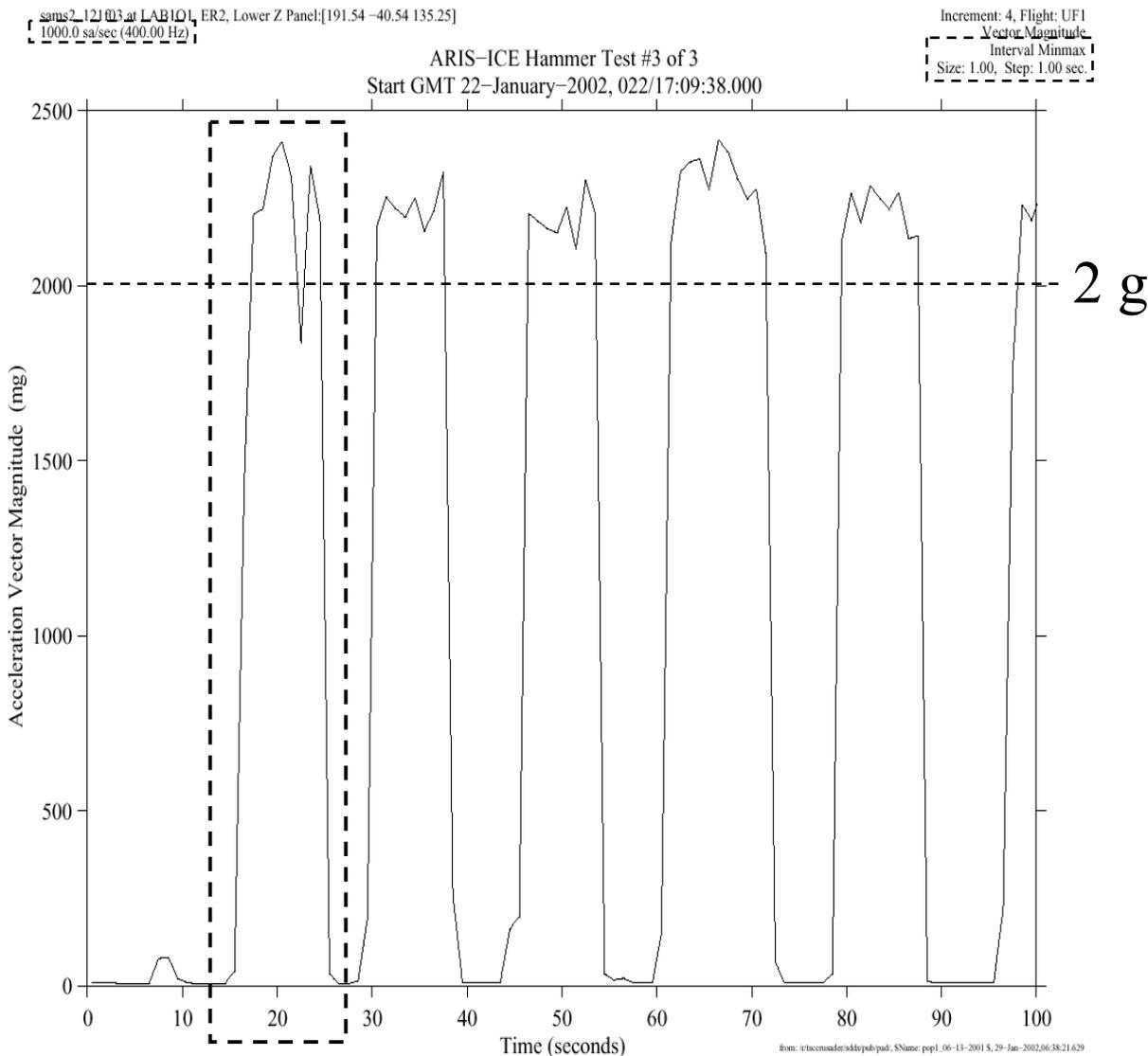


- **SENSOR:**
 - SAMS RTS 121f03
 - on Z-panel of ER2 (rack that was “whacked”)
- **SOURCE:**
 - Cleveland born Flight Engineer (FE-1) Carl Walz teaching ER2 a lesson it won't soon forget ... actually ... Carl's conducting hammer test for ARIS-ICE.
- **EFFECT:**
 - broadband

03/07/2002



ISS Measured Vibratory Environment Crew, Experiment Operations, Quantify



- **SENSOR:**
 - SAMS RTS 121f03
 - on Z-panel of ER2 (on rack that was “whacked”)
- **EFFECT:**
 - $f \leq 400$ Hz
 - PEAK: 2.4 g

- **SENSOR:**
 - SAMS RTS 121f04
 - on Z-panel of ER1 (adjacent to rack that was “whacked”)
- **EFFECT:**
 - $f \leq 400$ Hz
 - PEAK: 480 mg

- **NOTES:**
 - see ancillary text at top
 - dashed box on this slide corresponds to that on the next slide

03/07/2002



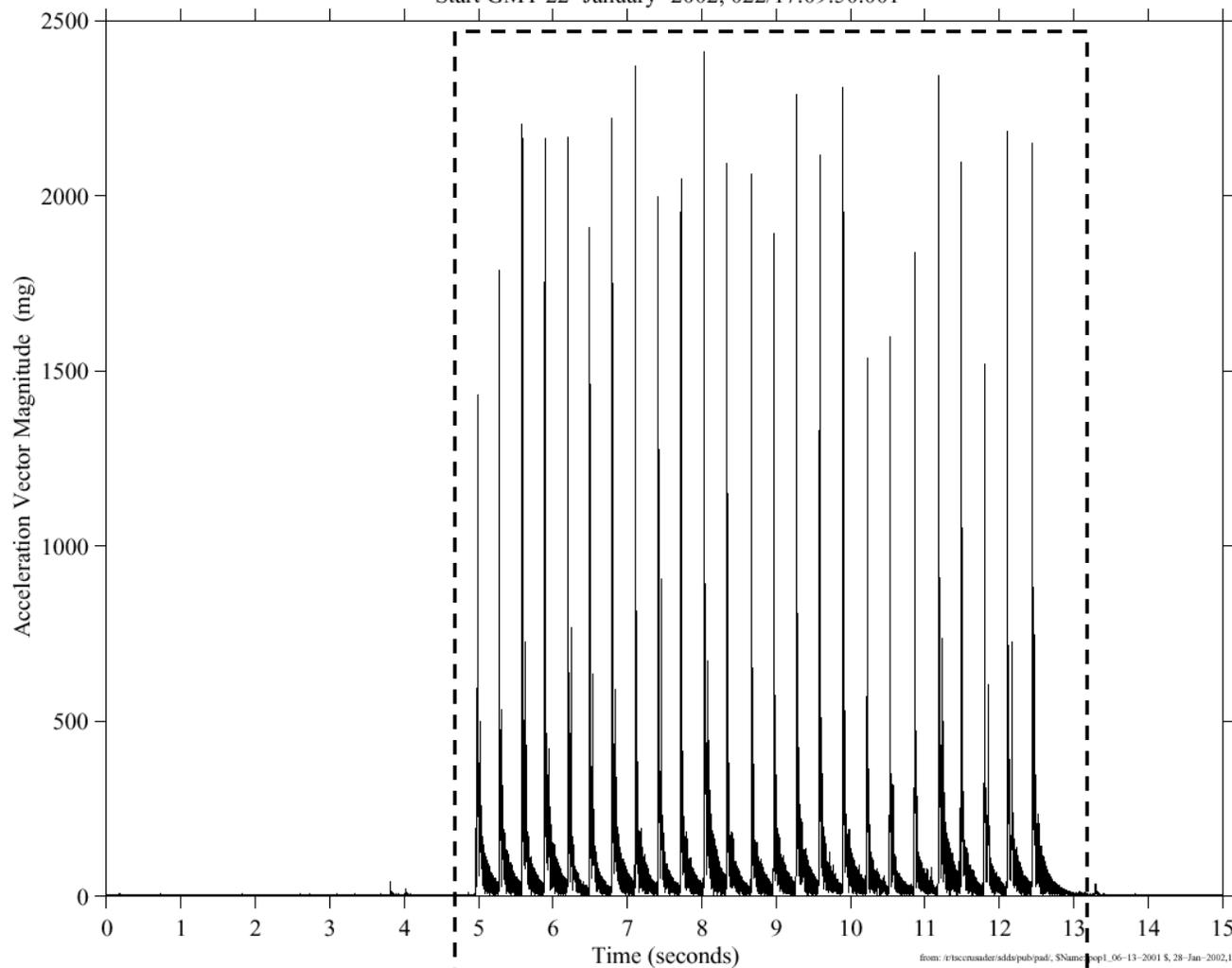
ISS Measured Vibratory Environment Crew, Experiment Operations, Clarify



sams2, 121f03 at LAB101, ER2, Lower Z Panel:[191.54 -40.54 135.25]
1000.0 sa/sec (400.00 Hz)

Increment: 4, Flight: UF1
Vector Magnitude

ARIS-ICE Hammer Test #3 of 3
Start GMT 22-January-2002, 022/17:09:50.001



- **NOTES:**
- dashed box on this slide corresponds to same on previous slide
- be careful when using the Tin Man's hat as done on previous slide; that is, interval statistics (like any good statistics) certainly do not tell the whole story



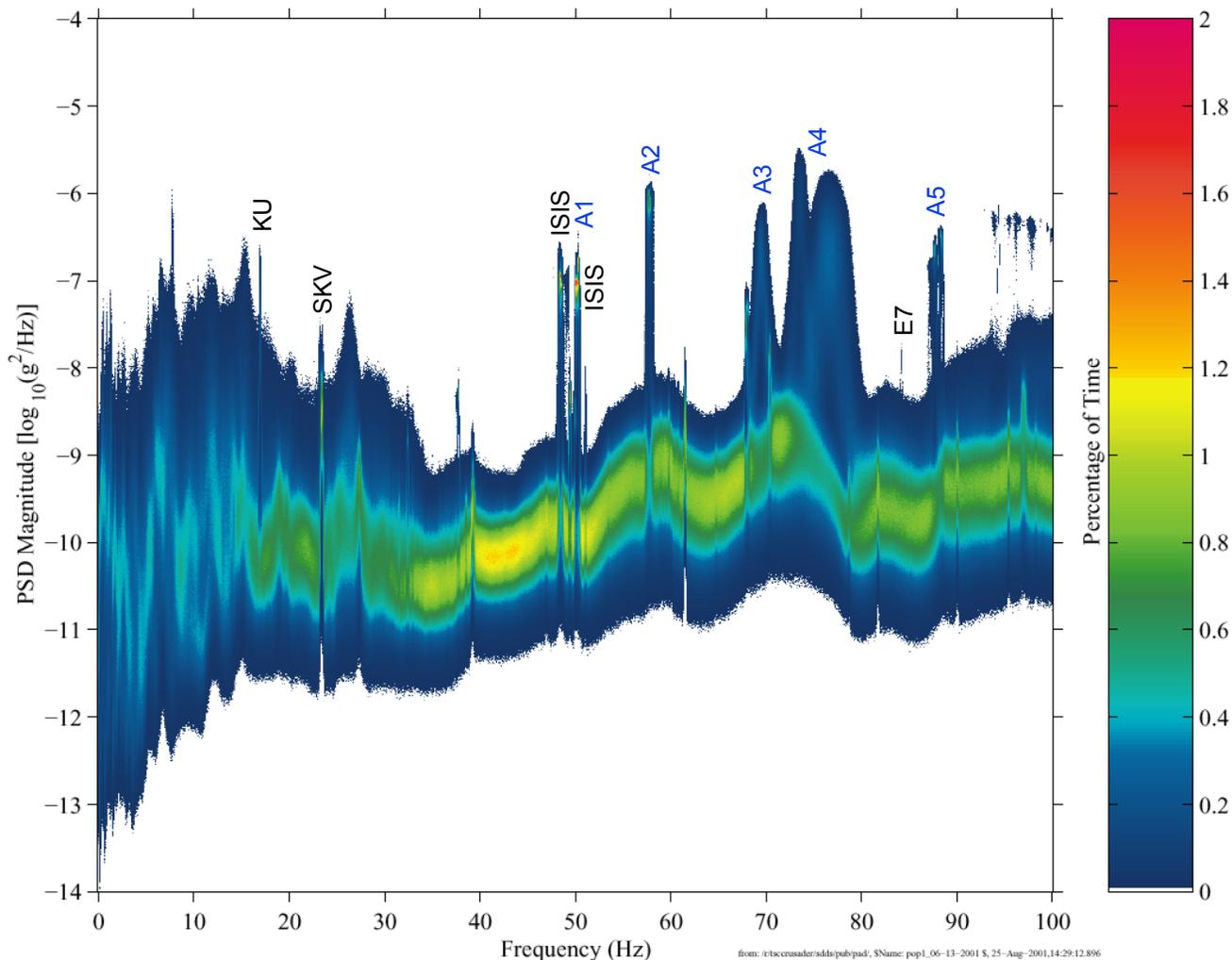
ISS Measured Vibratory Environment Increment 2 PCSA



mams, hirap at LAB102, ER1, Lockers 3,4:[138.68 -16.18 142.35]
1000.0 sa/sec (100.00 Hz)
 $\Delta f = 0.122$ Hz, Nfft = 8192
Temp. Res. = 8.192 sec, No = 0

MAMS HiRAP

Increment: 2, Flight: 7A
Sum
hanning, 262209 PSDs
Total of 596.7 hours



• LEGEND:

- KU: Shuttle's Ku-band antenna dither during docked operations
- SKV: air conditioner in Russian Service Module
- ISIS: International Subrack Interface Standard drawer fans
- A1: ADVASC fan
- A2: ADVASC pump
- A3*: ADVASC blower
- A4*: ADVASC blower
- A5*: ADVASC fan
- * frequency shift/smear
- E7: EXPPCS 7th harmonic

• NOTES:

- the axis box for this plot matches next slide

03/07/2002

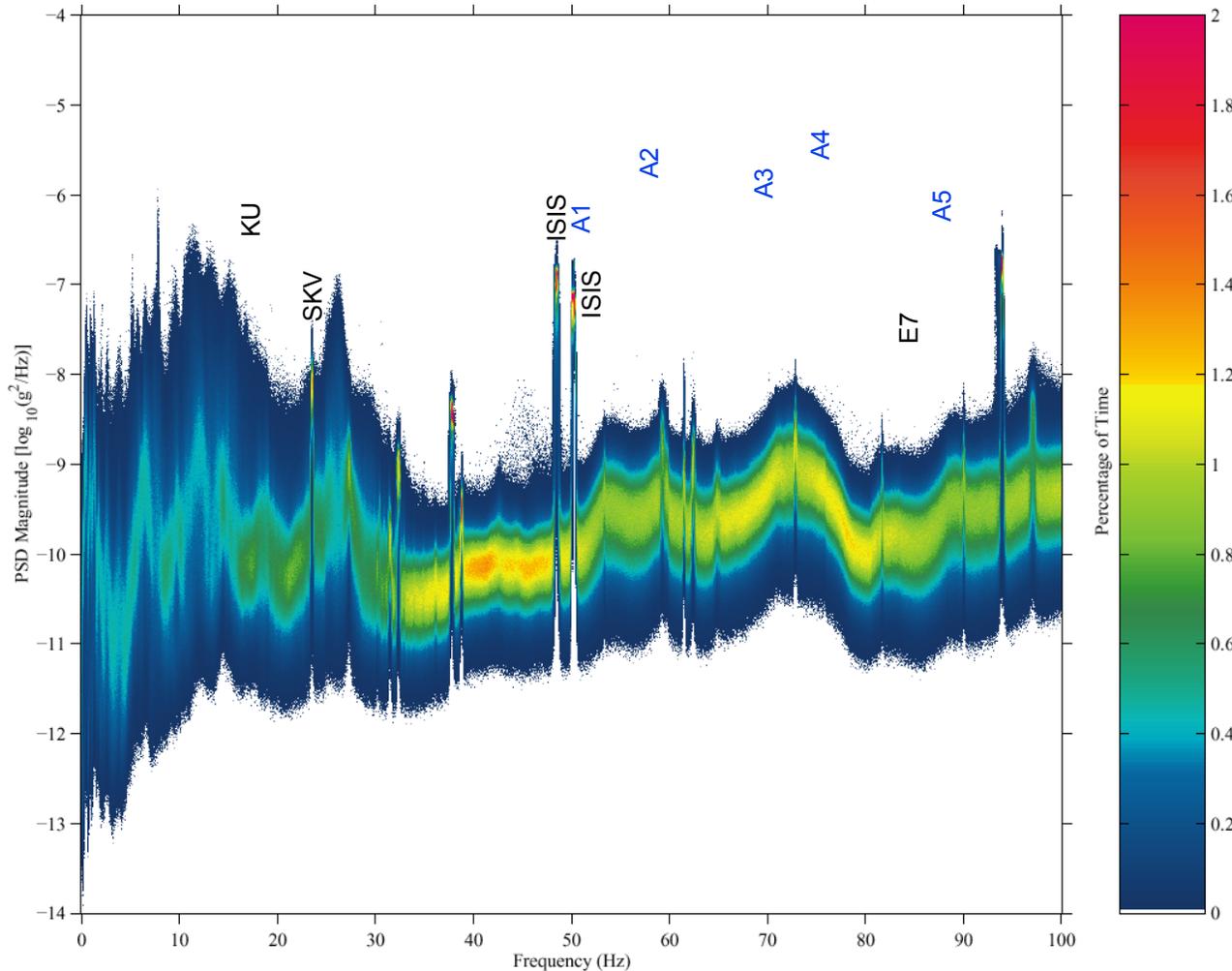
MEIT-2002 / Section 20 / Page 26

ISS Measured Vibratory Environment Increment 3 PCSA

mams, hirap at LAB102, ER1, Lockers 3,4-[138.68 -16.18 142.35]
1000.0 sa/sec (100.00 Hz)
Δf = 0.122 Hz, Nfft = 8192
Temp. Res. = 8.192 sec, No = 0

MAMS HIRAP

Increment: 3, Flight: 7A.1
Sum
hanning, 102694 PSDs
Total of 233.7 hours

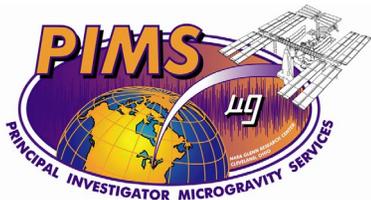


• **LEGEND:**

- KU: No Shuttle's Ku-band antenna dither because no docked operations
- SKV: air conditioner in Russian Service Module
- ISIS: International Subrack Interface Standard drawer fans
 - higher frequency fan overlaps vacated ADVASC (A1) fan disturbance at ~50Hz
- A1-A5: No ADVASC
- E7: No EXPPCS

• **NOTES:**

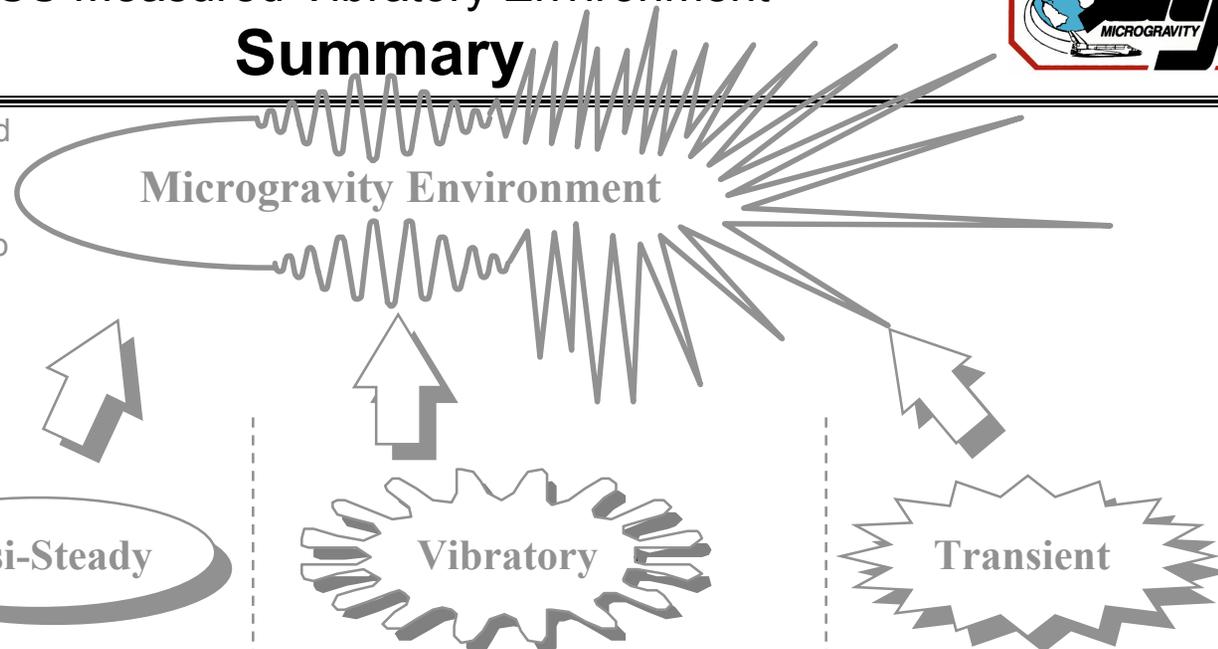
- the axis box for this plot matches previous slide



ISS Measured Vibratory Environment Summary



Microgravity - generic term applied to **scientific investigations that exploit or explore near weightlessness**; not a reference to a specific acceleration level



Component	Quasi-Steady	Vibratory	Transient
Frequency	$0 \leq f < 0.01 \text{ Hz}$	$0.01 \leq f \leq 300 \text{ Hz}$	broadband
Magnitude	less than a few μg	tens to thousands of μg_{RMS}	tens of mg's peak
Primary Sources	gravity gradient & rotational effects: not at center of mass drag: function of altitude, attitude, day/night, etc. vehicle: venting water or air	equipment: pumps, fans, centrifuges, compressors, etc. crew: ergometer, treadmill exercise vehicle: structural modes	vehicle: thrusters, dockings crew: pushoffs & landings, drawer/door closings, experiment setup equipment: machinery startup
Acceleration Measurement System	MAMS OSS (ISS) OARE (Columbia)	MAMS HiRAP SAMS	MAMS & SAMS



ISS Measured Vibratory Environment Vibratory Summary Table

Source	State	Effect	Frequency Range (Hz)	Sensor	GMT
Progress (4P) Docking	PEAK	13 mg	0 - 100	MAMS HIRAP	23-May-2001 00:24:23
Shuttle (7A) Docking	Softmate	PEAK: 10 mg	0 - 100	MAMS HIRAP	14-July-2001 03:08:31
Shuttle (7A) Docking	Hardmate	PEAK: 6 mg	0 - 100	MAMS HIRAP	14-July-2001 03:21:04
Shuttle (7A, 1) Docking	Softmate	PEAK: 29 mg	0 - 100	MAMS HIRAP	12-August-2001 18:42:25
Shuttle (7A, 1) Docking	Hardmate	PEAK: 14 mg	0 - 100	MAMS HIRAP	12-August-2001 19:02:35
SKV-1	OFF	RMS: 8 µg	23 - 24	SAMS 121f02	08-August-2001 00:00:08:00
SKV-1	ON	RMS: 37 µg	23 - 24	SAMS 121f02	08-August-2001 16:00:23:59
ADVASC	OFF	RMS: 0.3 mg	0 - 100	MAMS HIRAP	02-June-2001
ADVASC	ON	RMS: 1.0 mg	0 - 100	MAMS HIRAP	02-June-2001
EXPPCS	Sample Mix	PEAK: 150 mg	0 - 200	SAMS 121f06 ER2 test section	04-June-2001
EXPPCS	Sample Mix	PEAK: 22 mg	0 - 100	SAMS 121f03 ER2 Z-panel	05-July-2001
EXPPCS	Sample Mix	PEAK: 10 mg	0 - 100	SAMS 121f04 ER1 Z-panel	05-July-2001
MAMS Fan	OFF	RMS: 31.5 µg	182.3 - 183.7	SAMS 121f02	30-August-2001 15:42:30-15:44:42
MAMS Fan	ON	RMS: 95.6 µg	182.3 - 183.7	SAMS 121f02	30-August-2001 15:45:18-15:47:30
Crew	Sleep	RMS: 9 µg	0.06 - 6	MAMS HIRAP	03-June-2001 08:40:00-08:44:00
Crew	Wake	RMS: 40 µg	0.06 - 6	MAMS HIRAP	03-June-2001 08:48:00-08:52:00
EXPPCS	Activation	RMS: 0.12 mg	119.55 - 119.71	SAMS 121f03	21-August-2001, 233/16:11:46
Progress 4P Undocking		PEAK: 1.02 mg	0 - 25	SAMS 121f02	22-August-2001, 234/06:07:14
Progress 5P Thruster Test		PEAK: 1.93 mg	0 - 25	MAMS HIRAP	27-August-2001, 239/01:34:36
Progress 5P Thruster Test		PEAK: 3.03 mg	0 - 25	SAMS 121f05	27-August-2001, 239/01:34:00
Progress 5P Thruster Test		PEAK: 2.78 mg	0 - 25	SAMS 121f06	27-August-2001, 239/01:34:00
Progress 5P Docking		PEAK: 18.72 mg	0 - 100	MAMS HIRAP	23-August-2001, 235/09:52:19
Structural Modes	STS-108 Joint Ops				
Structural Modes	STS-108 Unmated				
SEE INCREMENT 3 REPORT					
STS-108 Joint Ops Shuttle Ergometer Exercise	NOT typical	RMS: 150 µg	0 - 25	SAMS 121f03	15-December-2001, 349/11:37:15
ARIS Environment Comparison	non-isolated ARIS active	PEAK: 315 µg	0 - 25	SAMS 121f05	
		PEAK: 25 µg	0 - 25	SAMS 121f06	11-September-2001, 254/08:09:19

This table aims to summarize results from the vibratory acceleration analysis for PIMS' Increment 2 and 3 reports. As such, *it does not completely characterize the event under consideration*. The column labeled "Effect" in the table is an attempt to encapsulate the impact of the corresponding "Source" acceleration event on the vibratory regime. The quantities referred to in the "Effect" column are one of the following:

- PEAK, the peak acceleration vector magnitude
- RMS, the acceleration root-mean-square value for the frequency range shown